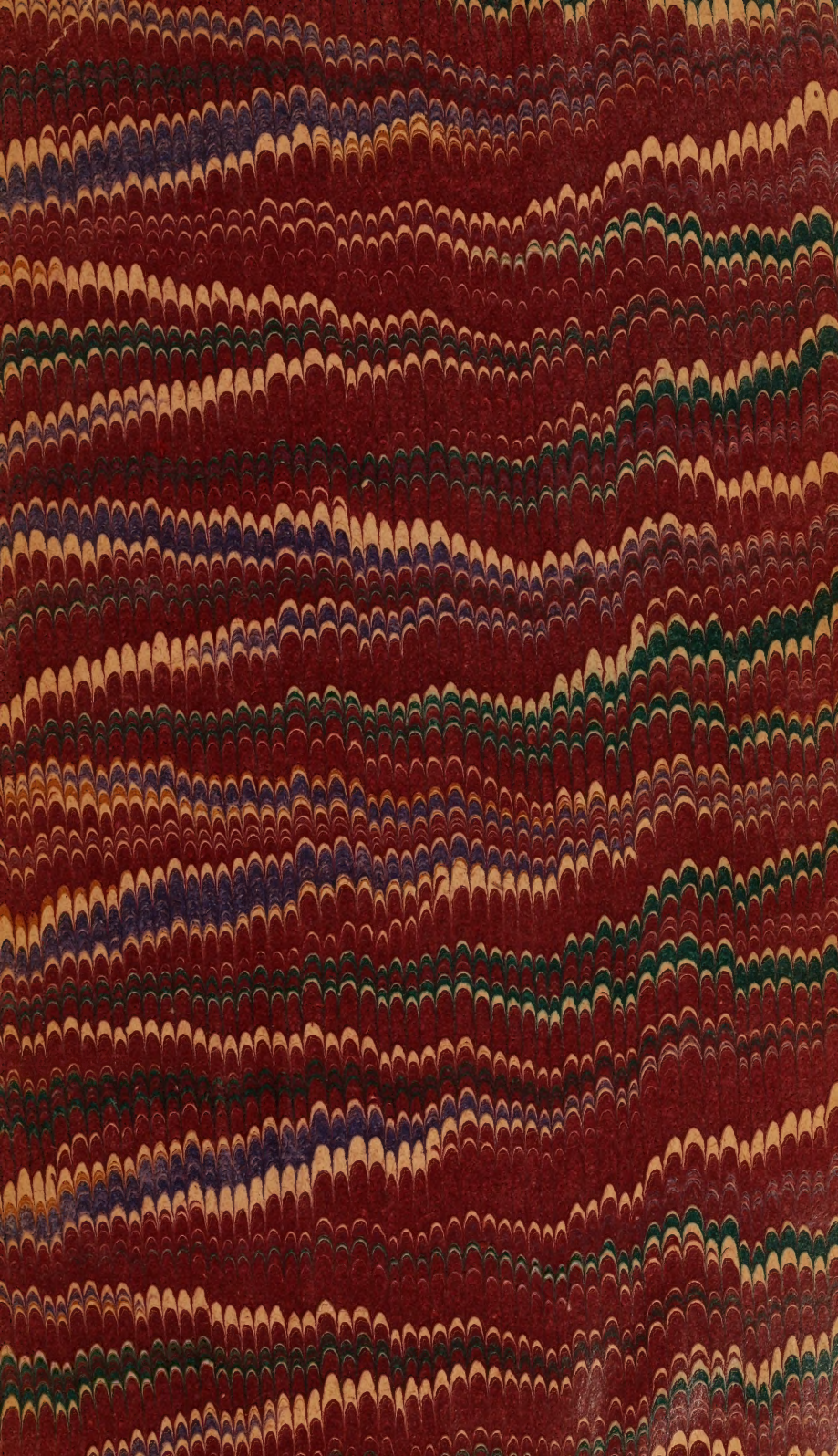


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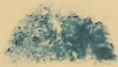






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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 17.

THE
CHINCH BUG:

A GENERAL SUMMARY OF ITS HISTORY, HABITS, ENEMIES, AND OF
THE REMEDIES AND PREVENTIVES TO BE USED AGAINST IT.

By L. O. HOWARD, M. S.,
ASSISTANT ENTOMOLOGIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 3, 1888.

SIR: I have the honor to submit for publication Bulletin No. 17 from this Division, being a paper upon the Chinch Bug prepared by my first assistant, Mr. L. O. Howard, for the forthcoming Annual Report. There are several important, or what the late Dr. LeBaron called "first class," injurious insects, like the Chinch Bug, which I have so far not cared to treat of in the publications of the Division, because in past years, while State Entomologist of Missouri, I had occasion to publish pretty fully upon them and because there is little opportunity to make further investigations or experiments upon them in the vicinity of Washington. I have, however, endeavored to keep a record of everything published in reference to them and of the advance in our knowledge of improved means of controlling them. On account of the great interest felt just now in the Chinch Bug and the prospect of injury from it the coming summer in the Mississippi Valley, and from the fact that the principal work to be done in preventing such injury is winter work, I have decided, with your approval, to issue this paper in advance as a bulletin, in order to supply the constant demand for information upon the insect at the present time. It may be looked upon as an emergency bulletin published because of the probable delay in the appearance of the more bulky annual report beyond the time when the information will be useful for the coming season.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

THE CHINCH BUG.

(*Blissus leucopterus*, Say.)

Order HEMIPTERA ; family LYGÆIDÆ.

INTRODUCTORY.

The present treatment of the Chinch Bug offers little scope for anything new or original. It is an extremely destructive species which has been exhaustively treated by former writers and which, after several years of comparative scarcity, has again become very injurious, so much so as to occasion the loss of millions of dollars during the past season and to call forth the greatest variety of comment from the press of the country, agricultural or otherwise. In this emergency it happens that there are no public documents for distribution and even no books which can be purchased which treat of the life history of and remedies for this pest. The State reports of Riley and LeBaron are out of print; the small edition of Bulletin 5 of the U. S. Entomological Commission, by Dr. Thomas, was long since exhausted; and the recent bulletin and circular by Forbes treat almost solely of remedies.

It becomes necessary, therefore, to bring out once more a complete review of the subject. Previous writings, particularly those of Riley, are freely used, and in many instances the well-known Missouri reports of my chief are quoted at length.

Observations by Prof. Herbert Osborn, F. M. Webster, W. B. Alwood, and Miss Mary Murtfeldt, Agents of the Division, are acknowledged as they are used. Indebtedness to Prof. G. F. Atkinson, of Chapel Hill, N. C., for observations made in his vicinity, is here acknowledged. The note-books of the Division of Entomology and the extensive records for many years collected by Professor Riley have been at my disposal.

PAST HISTORY.

It has been quite generally accepted that the Chinch Bug is, comparatively speaking, a Southern rather than a Northern insect, and in so far as the matter of destructive appearances goes, this idea is well upheld by its past history. In our section upon geographical distribution, however, we have shown that the species is by no means confined to the more Southern States, but that it is often found north of the

boundary line, in Canada. It was first noticed, so far as we can find, in North Carolina, at the close of the Revolutionary war, where, as has been so often stated, it was mistaken for the Hessian fly, which at that time was attracting considerable notice on Long Island and thereabouts.

Dr. Fitch, in his second report, gives with some little detail an account of its early appearances, from which we may simply state that after this first notice the insect did considerable damage for several years in North Carolina, South Carolina, and Virginia. After a short series of seasons it was again destructive in North Carolina in 1809, so that in Orange County the cultivation of wheat was abandoned for two years.

In 1839, in the same States, great damage was done to corn and wheat, and in 1840 an increase in number occurred, and the wholesale destruction of the crops was only prevented by an exceedingly wet season.

The first scientific description of this species was given by Say in 1831, in a pamphlet, now very scarce, published at New Harmony, Ind., entitled "Descriptions of new species of Heteropterous Hemiptera," from a single specimen collected on the eastern shore of Virginia, and it was probably at that time rare in Indiana, where Say resided, at New Harmony.

It attracted much attention in 1840 in Illinois when it occurred in numbers in Hancock County, where it was supposed to have been introduced by the Mormons, and was called in consequence the "Mormon louse."

According to Professor Riley, the first recorded appearance of the insect in Missouri was in 1839. It was again noticed in 1844, and has been destructive at intervals ever since. In Iowa its first recorded appearance is in 1847, in Indiana in 1854, and in Wisconsin in 1855.

Eighteen hundred and sixty-four was a year marked by damage in these Western States. In 1868, a season of great drought, much damage was done by the bugs in Missouri.

In 1871 great damage was done in Illinois, southern Iowa, in parts of Indiana, in Nebraska, in southern Missouri, and Kansas. It was estimated by Dr. LeBaron in his second Illinois report that the loss to the wheat, oat, and barley crops during this year amounted to \$10,500,000 in Illinois alone, and in the other six States mentioned, including Indiana, the total loss was upwards of \$30,000,000.

In 1874 they occurred again in Missouri and the adjoining States in exceptional abundance. It was during this season that Professor Riley sent out circulars to all parts of Missouri and at the close of which he wrote the extended article which was published in his Seventh Report on the Insects of Missouri.

He estimated that the total loss to the group of States of which eastern Kansas forms a center was double that of 1871. Very careful estimates by counties gave an aggregate loss of \$19,000,000 for

Missouri alone, including only the three staple crops of Wheat, Corn, and Oats. He mentions several facts which tend to show that this estimate is low rather than high. In this report Professor Riley also gave the first accurate and extended descriptions of the adolescent stages, including the egg, and noticed the differences between the number of joints in the tarsi in the young and the adult.

From 1874 to 1881 there were no serious irruptions of this pest, but in this year it attracted considerable notice and did a great deal of damage in some Western States. Much newspaper literature concerning the insect was published during this year, much of which was excited by Thomas's paper upon the "Relation of Meteorological Conditions to Insect Development and Particularly to the Chinch Bug." It was during this year also that the "Chinch Bug convention" was held at Windsor, Kans., and it was decided to exclude Wheat from cultivation as a means of extirpating the pest.

In 1882 the work of the bug upon timothy grass was discovered in Saint Lawrence County, N. Y., for the first time in its history. It increased and spread in 1883, exciting great alarm, and occasioned several articles from the pen of Dr. Lintner, who also issued a circular on remedies and anticipating further damage.

Professor Riley in Science (Vol. II, p. 620) and in his Report for 1884 stated that there was little cause for alarm in New York, and indeed no particular damage has since been recorded. In 1885 some damage was done in parts of Kansas and Nebraska, and in 1886 still more. Bulletin No. 13 of the Division of Entomology contains reports of considerable damage in the spring of 1886 from Kansas, Indiana, Ohio, and Nebraska and more especially in southern Illinois.

During the past year (1887) the injury was marked in these States and also in some parts of Missouri, but the interesting point in the history of this season has been the occurrence of the insect in immense numbers in portions of Virginia and North and South Carolina for the first time in many years. As a thorough review of the localities and damage this season is desirable, a statement has been drawn up at my request by Mr. J. R. Dodge, the statistician of this Department, which is submitted herewith.

Mr. Dodge reports as follows:

In accordance with your request, I take pleasure in communicating the results of inquiries made relative to the geographical distribution of Chinch Bugs during the past season, and to the extent of their destruction of growing crops.

I find indications of their presence throughout the southern and western States, but no material injuries to crops are reported except in States bordering on the Mississippi River and the Lower Missouri. Kansas, part of Nebraska, Missouri, Iowa, Illinois, southern Wisconsin, and eastern Minnesota include practically the field of their serious operations.

They attacked wheat and rye first, then barley and oats, and afterward corn, grass, millet, sorghum, and broom-corn. As corn, wheat, and oats are the principal tilled crops of this area, they represent the principal part of the damage.

In many places the fields were cleared, and small grain areas were ploughed up. The pest came in some cases to districts that had never before been ravaged; in many others the scourge was claimed to be more sweeping than ever before.

The insect was present in injurious numbers in nearly every county in Kansas. Correspondents in Leavenworth, in the extreme east, and Hamilton, on the Colorado border, gave the only negative replies. The worst damage was done in this State.

The infliction was general in Missouri, except in a belt in the central part of the State, not very regular nor wholly untouched, trending northeasterly, and connecting with a similar belt in Illinois.

Further north, no portion of Iowa was exempt, except the northwest corner of the State, in proximity to areas of exemption from central Minnesota westwardly through Dakota, and near to a similar area in northern Nebraska. In eastern Minnesota and southern Wisconsin, however, the scourge was general and severe. In Illinois comparative exemption was enjoyed in a central belt running in a northeasterly direction from Christian to Champaign, and from Adams to Bureau, fifteen to twenty counties, in which correspondents responded in the negative as to their destructive presence. Elsewhere the pest was nearly universal.

The southwestern corner of Indiana was alive with Chinch Bugs; elsewhere, though present in much of the area, only about a dozen counties estimated any material losses. They were still scarcer in Michigan. Only ten counties in Ohio reported their injurious presence; and a few only in Kentucky indicated material damage.

These insects are reported as more or less injurious in every season of drought and scarce or absent in all wet areas. In the area of their depredations the crops have an annual value of more than a fourth of the entire agricultural production of the United States, and a value nearly four times as great as that of the cotton crop. It will readily be seen that the losses must be heavy, undoubtedly greater than those of all other insects together, as no such values are involved in other crops subject to insect depredations the past year.

The following table has been prepared from data, severely scrutinized, revised, and accurately consolidated. It makes a large sum, and yet does not comprise all the damage done to barley and rye, millet, etc., all of which might be approximately stated in round numbers as \$50,000,000. The record by States is as follows:

States.	Corn.		Wheat.		Oats.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Kentucky	983, 280	\$521, 138	66, 678	\$48, 675	.....	.....
Ohio	885, 564	425, 071	215, 370	161, 528	60, 196	\$19, 263
Indiana	1, 785, 000	803, 250	453, 936	326, 834	167, 658	48, 621
Illinois	16, 929, 600	6, 941, 136	5, 529, 150	3, 870, 405	3, 810, 310	1, 028, 784
Wisconsin	1, 804, 250	757, 785	3, 004, 490	1, 922, 874	1, 742, 750	487, 970
Minnesota	2, 169, 720	802, 796	9, 074, 750	5, 354, 103	2, 438, 160	633, 922
Iowa	22, 020, 240	7, 707, 084	6, 977, 620	4, 256, 348	4, 162, 920	1, 071, 101
Missouri	15, 504, 390	5, 736, 624	1, 664, 640	1, 032, 077	795, 860	206, 924
Kansas	16, 840, 340	6, 230, 926	2, 282, 100	1, 392, 081	6, 406, 560	2, 438, 497
Total.....	78, 922, 384	29, 925, 810	29, 268, 734	18, 364, 925	19, 884, 414	5, 935, 082

Respectfully,

J. R. DODGE,
Statistician.

Accompanying these statements of Mr. Dodge were a number of State maps indicating the counties reporting to the Department damage from the Chinch Bug. Many other localities had Chinch Bugs in abundance and considerable damage was done in States not represented in

this list. These localities, however, are authoritative, and their reports furnished the main basis for the table which precedes. We may summarize these briefly as follows:

Illinois, fifty-one counties, as follows: Stephenson, Winnebago, Lake, Carroll, Lee, Kendall, Will, La Salle, Rock, Mercer, Warren, Stark, Iroquois, Vermillion, Edgar, Douglas, Coles, Moultrie, Shelby, Cumberland, Clark, Jasper, Effingham, Fayette, Bond, Madison, Macoupin, Greene, Pike, Jersey, Saint Clair, Clinton, Washington, Marion, Clay, Lawrence, Wabash, Edwards, White, Hamilton, Franklin, Randolph, Jackson, Williamson, Saline, Gallatin, Johnson, Pope, Hardin, Massac, and Alexander.

Indiana, twenty-five counties, as follows: Elkhart, Jasper, White, Huntington, Wells, Blackford, Jay, Warren, Montgomery, Wayne, Shelby, Johnson, Sullivan, Greene, Dearborn, Knox, Martin, Ohio, Gibson, Pike, Dubois, Posey, Vanderburgh, Warrick, and Spencer.

Iowa, sixty-one counties, as follows: Winnebago, Worth, Mitchell, Howard, Winnesnick, Allamakee, Clayton, Fayette, Chickasaw, Floyd, Cerro Gordo, Hancock, Palo Alto, Pocahontas, Humboldt, Franklin, Dubuque, Buchanan, Grundy, Hamilton, Webster, Calhoun, Sac, Crawford, Carroll, Greene, Story, Marshall, Tama, Benton, Linn, Jackson, Clinton, Scott, Muscatine, Iowa, Jasper, Dallas, Guthrie, Audubon, Shelby, Madison, Mahaska, Keokuk, Des Moines, Henry, Monroe, Lucas, Union, Adams, Montgomery, Mills, Fremont, Page, Taylor, Decatur, Wayne, Appanoose, Davis, Van Buren, Lee.

Kansas, sixty-three counties, as follows: Cheyenne, Rawlins, Norton, Phillips, Jewell, Washington, Marshall, Nemaha, Brown, Wyandotte, Jefferson, Jackson, Shawnee, Douglas, Pottawatomie, Riley, Wabaunsee, Davis, Clay, Cloud, Mitchell, Rooks, Graham, Sheridan, Thomas, Sherman, Gove, Russell, Lincoln, Ottawa, Ellsworth, Saline, Dickinson, Morris, Osage, Franklin, Miami, Linn, Anderson, Coffey, Chase, Marion, McPherson, Rice, Barton, Rush, Ness, Lane, Scott, Ford, Pawnee, Stafford, Reno, Sedgwick, Allen, Neosho, Cherokee, Labette, Chatauqua, Cowley, Sumner, Barbour, Comanche.

Kentucky, eight counties, as follows: Carroll, Pendleton, Bracken, Estill, Mercer, Union, Ballard, Marshall.

Michigan, five counties, as follows: Manitou, Presque Isle, Saginaw, Shiawassee, Saint Joseph.

Minnesota, twenty-seven counties, as follows: Hubbard, Wadena, Todd, Crow Wing, Kanabec, Pine, Isanti, Chisago, Sherburne, Stearns, Wright, Carver, Scott, Rice, Wabasha, Winona, Olmstead, Dodge, Steele, Waseca, Watonwan, Martin, Faribault, Freeborn, Mower, Fillmore, and Houston.

Missouri, sixty counties, as follows: Atchison, Nodaway, Holt, Worth, Gentry, Harrison, Mercer, Putnam, Sullivan, Adair, Linn, Clinton, Caldwell, Ray, Chariton, Randolph, Lincoln, Saint Charles, Callaway, Copper, Johnson, Cass, Bates, Henry, Saint Clair, Hickory, Osage, Maries, Gasconade, Franklin, Jefferson, Washington, Sainte Genevieve, Perry, Iron, Bollinger, Cape Girardeau, Mississippi, New Madrid, Butler, Wayne, Oregon, Shannon, Pulaski, Laclede, Wright, Douglas, Ozark, Christian, Webster, Dallas, Hickory, Polk, Cedar, Dade, Barton, Lawrence, Barry, Newton, and McDonald.

Ohio, ten counties, as follows: Defiance, Wood, Geauga, Allen, Shelby, Darke, Franklin, Fairfield, Meigs, and Gallia.

GEOGRAPHICAL DISTRIBUTION.

East of the Rocky Mountains the Chinch Bug seems to be indigenous North and South, feeding naturally upon various species of wild grasses and becoming multiplied wherever the cultivation of wheat has reached its original haunts.

It was first noticed, as stated in the last section, in North Carolina, and Say's original description was published from a Virginia specimen.

Fitch records the fact that he had collected specimens in New York, but that it was exceedingly rare. Signoret also records it from New York, and, as we have just shown, it appeared in 1883 in destructive numbers in the northern part of this State. Harris in the first edition of his well-known work states that it does not occur in New England, but in a foot-note to his second edition states that while the sheet was passing through the press he discovered a single specimen in his own garden at Cambridge (June 17, 1852). And in 1883, according to Dr. George Dimmock (*Psyche*, November, December, 1883, p. 119), the lowland between Belmont and Cambridge was swarming with them. They have also been collected by Dr. Packard at Salem, Mass., in Maine, and at the summit of Mount Washington in New Hampshire. Dr. Lintner records the fact that Mr. H. L. Fernald captured one or more specimens in 1879, 1880, and 1882, at Orono, Me.

In Canada they occurred at Grimsby, Ontario, in 1866, and were sent from that point in that year to Mr. Walsh. Mr. W. H. Harrington collected specimens found abundantly at Sydney, Cape Breton (N. lat. 46° 18') in September, 1884 (*Can. Ent.*, November, 1884, p. 218). Dr. Fitch received specimens from western Pennsylvania, and also stated that it was sent him from Mississippi with the information that in some years it damaged the crops of Indian corn. We have found it personally in considerable numbers in the rice fields near Savannah, Ga., and Mr. E. A. Schwarz and others have collected it in Florida. In the latter State Mr. Schwarz found it very abundantly at Biscayne Bay, breeding in the wingless form only in considerable numbers upon Sand Oats (*Uniola paniculata*). Mr. Webster has noticed it in Mississippi and Louisiana. It has also been collected in this same form, upon the same plant, on the sea-shore at Fortress Monroe, Va., by Messrs. Schwarz and Heidemann. The States, however, in which it does the greatest damage are Virginia, North Carolina, South Carolina, Ohio, Indiana, Kentucky, Tennessee, Illinois, southern Wisconsin, Iowa, Missouri, Kansas, and Nebraska. Uhler records the species from Texas, California, Kansas, Nebraska, Wisconsin, Minnesota, Illinois, Michigan, and generally throughout the Atlantic region.

Outside of the United States it is recorded only from Cuba (see Signoret "*Essai Monographique du Genre Micropus, Spinola*;" *Ann. Soc. Ent. France*, V, 3d series, 1857, p. 31), and the Cuban individuals are long-winged, while Mr. Schwarz never found a long-winged individual in Florida, in spite of the fact that he has collected in localities the insect fauna of which is in the main Cuban. This observation conflicts with the general observation of Mr. Uhler that the short-winged form seems to be more common in New England than in the Southern States.

The only authentic published record of the occurrence of the Chinch Bug west of the Rocky Mountains is the mere mention by Uhler, in his list of

the Hemiptera of the region west of the Mississippi River (Bull. Hayden Surv. I, 306), of California as one of the States which it inhabits, but this record has been overlooked by Californians. Its advent upon the Pacific slope has been expected and dreaded. Matthew Cooke in his book, published in 1883, upon injurious insects of the Orchard, Vineyard, etc., figured and described it, and under the head of "Remedies" wrote, "Should the pest appear in this State it can be prevented," etc.

In June, 1885, there were several newspaper reports on the occurrence of this insect in great numbers in California. The San Francisco Evening Post for June 23, 1885, quoting from the Woodland Democrat, published the statement:

Messrs. Frazee and Henderson, who live southwest of Woodland, brought to this office a bottle of this pestiferous insect (chinch bug) on Tuesday. Mr. Henderson says that he recognized them as the same eastern variety that frequently does so much injury to wheat in Missouri. These gentlemen say they discovered the bugs traveling between the lands of Day and Clanton. There are millions of them, but as to the extent of country covered they are unable to say. The bugs are nearly grown and are just beginning to have wings. As soon as the wings develop they fly and scatter everywhere. Mr. Frazee says there is no danger from them this year as the grain is too far advanced.

So far this item seems very plausible, but it goes on to state "that another gentleman had noticed them injuring grape-vines" which of course introduces a probability of wrong identification.

There is no question, however, but that the Chinch Bug is to be found at present in California, but there is no assurance of its existence in injurious numbers. Our certainty as to its presence arises from the fact that a single specimen of a short-winged variety of this insect is among a lot collected in the vicinity of San Francisco in 1885 by Mr. Koebele. It is unquestionably a true Chinch Bug. Another specimen of the same variety was collected in 1884 by some students of Johns Hopkins University who summered in California and was given to Mr. Lugger, of this Division, who was at that time connected with the University. Recent communications from California in answer to inquiries on this point show that the insect is not known to the entomologists in that State. The False Chinch Bug (*Nysius angustatus*) has been, we learn from Mr. Koebele, very destructive to grapes in that State the past season, and it is more than likely that this is the insect referred to in the newspaper article just quoted. Mr. Koebele writes that the False Chinch was so abundant around Alameda in July that in an old road at least 50 specimens could be counted under each plant of *Polygonum aviculare*. He made, in 1887, a most careful search of the locality in which he found the 1885 specimen, but could not find a single additional individual. He also examined the large collection of Hemiptera in the California Academy of Sciences without success. The following paragraph is from Mr. Coquillett's answer to our inquiries:

I have never met with the Chinch Bug in any part of California that I have visited—neither in Merced County, around the city of Sacramento, nor on the southern part of

the State, where I have collected Hemiptera extensively with the sweep-net. Dr. Rivers, curator of the museum at our State University, writes me that three years ago he took three specimens of a bug that looked much like the Chinch Bug, but was darker and smaller, and he does not believe that they belonged to this species; they were taken in Sonoma County, and were sent off, he knows not where. He has collected Hemiptera extensively since then, but the Chinch Bug is not among them. Mr. Wickson, editor of the Pacific Rural Press, writes me that he has "never seen a specimen nor heard of one as being recognized by an observer whom I would consider as capable of recognizing the insect."

Since writing the above we have learned from Mr. Uhler that he has seen specimens of the Chinch Bug from California of a long winged form, which were collected near San Francisco, probably by Mr. Henry Edwards. He has also seen specimens from Cuba and from Tamaulipas, Mexico.

FOOD PLANTS.

The Chinch Bug will feed upon all grains and grasses so far as known. The most prominent crops which are seriously injured are Wheat, Barley, and Indian Corn. The testimony in regard to Oats is conflicting, but Le Baron's conclusion to the effect that "if this grain be sown where Chinch Bugs abound, and especially if it is sown exclusively, it will be damaged to a greater or less extent the first year, but that the bugs will probably not continue to breed in it to any great extent in succeeding years" is unquestionably correct. Broom-corn, Sorghum, Chicken-corn, Hungarian grass, Millet, Rye, Rice, Bermuda grass (*Cynodon dactylon*), Fox-tail grass (*Setaria glauca*), Timothy (*Phloeum pratense*), Blue-grass (*Poa pratensis*), Crab-grass (*Panicum sanguinale*), Bottle-grass (*Setaria viridis*), and all of our wild grasses, so far as known, are attacked, but beyond these no food plant has ever been authentically recorded. Reports of damage done to other crops, such as grape-vines and garden crops, are the result of mistaken identity, and an error in the compilation of Packard's Guide to the Study of Insects has doubtless done much to perpetuate the idea that this insect is a more general feeder. This was corrected in the later editions of this work, probably at the suggestion in Professor Riley's criticism in his 7th Rept. Ins. Mo., p. 26.

Upon the Sand Oats (*Uniola paniculata*) in Florida Mr. Schwarz noticed that the entire development of the insect is undergone upon the highest part of this tall plant and not close to the bottom as in our latitude. The probable reason for this, as he has pointed out, is, that the strong winds are continually blowing fine, sharp sand through the lower parts of the plants, rendering it impossible for the bugs to remain at these places and forcing them to seek their nourishment higher up.

Concerning Timothy and the Crab-grasses Professor Forbes says:

It seems to prefer timothy to blue grass, not really relishing either as a general thing, and takes to the crab-grasses (*Panicum*) not at all, or only as a last resort. (Bull. No. 2, State Ent. Ill.)

This generalization is undoubtedly correct for Illinois and the surrounding States, but, as Professor Forbes himself points out in a foot-

note, the bugs did great damage to Timothy in northern New York in 1883, and the following extract from a letter recently received from Professor Atkinson, of North Carolina, indicates that in that State at least the Crab-grass becomes an important item of the insect's diet.

* * * I have recently discovered that at this season of the year (October 2) the chinch bug feeds on the "crab-grass" so common in cultivated and waste places, and especially so abundant in many of the corn-fields after cultivation has ceased. The chinch bug must go to grass after the corn becomes mature and no longer yields the sap. I have found the bugs inside the sheath and clear evidence of their having punctured the culm. No doubt this grass affords them subsistence for quite a period of time and then shelter for the winter. * * * I have found within the past few days pupæ or wingless individuals on the crab-grass. * * *

Referring again to Timothy we may state that a meadow of this grass on the farm of J. F. Whiton, near Wakeman, Huron County, Ohio, was injured considerably by the bugs in 1886. Professor Forbes, however (Bull. 2), gives an instance where sowing Timothy with Fall Wheat was probably the cause of the salvation of the crop.

On cultivated Rice we found Chinch Bugs very generally scattered throughout the large rice-fields near Savannah, Ga., in August, 1881. Only adult specimens were found at that time and all were fully winged, and were found upon the heads of the grain, to which they had probably flown, as the fields had been flooded for some time previously. No particular damage to the crop was perceptible, unless their punctures contribute to bring about the disease known as "white blast," as suggested by Professor Riley in his Annual Report for 1881-'82, page 137.

We shall probably be obliged to widen our close restriction of the Chinch Bug food plants, to admit at least one of the Polygonums. A chance statement by Mr. Bruner that he had known this insect to feed upon the so called "Wild Buckwheat" in Nebraska led to a letter of close inquiry, to which he replied that there can be no mistake and that the plant is either *Polygonum dumetorum*, or *P. convolvulus*.

STAGES OF GROWTH—DESCRIPTIVE.

The following descriptive matter is from Professor Riley's Seventh Report on the Insects of Missouri, and is fuller and more careful than that published elsewhere. It will be noticed that there are three larval stages, necessitating two molts before the pupa and three before the adult. It will also be noticed that the larvæ have but two joints to the feet, while the adults have three:

The Egg.—(Fig. 1a, b.) Average length 0.03 inch, elongate oval, the diameter scarcely one-fifth the length. The top squarely docked, and surmounted with four small rounded tubercles near the center. Color when newly laid, pale and whitish and translucent, acquiring with age an amber color, and finally showing the red parts of the embryo, and especially the eyes toward the tubercled end. The size increases somewhat after deposition, and will sometimes reach near 0.04 in length.

Larval Stages.—The newly-hatched larva (Fig. 1c) is pale yellow, with simply an orange stain on the middle of the three larger abdominal joints. The form scarcely

differs from that of the mature bug, being but slightly more elongate; but the tarsi have but two joints (Fig. 4d), and the head is relatively broader and more rounded, while the joints of body are sub-equal, the prothoracic joint being but slightly longer than any of the rest. The red color soon pervades the whole body, except the first two abdominal joints, which remain yellowish, and the members, which remain pale. After the first molt (Fig. 1e) the red is quite bright vermilion, contrasting strongly with the pale band across the middle of the body, the prothoracic joint is relatively longer, and the metathoracic relatively shorter. The head and prothorax are dusky and coriaceous, and two broad marks on mesothorax, two smaller ones on metathorax, two on the fourth and fifth abdominal sutures, and one at tip of abdomen are generally visible, but sometimes obsolete; the third and fourth joints of antennae are dusky, but the legs still pale. After the second molt (Fig. 1f) the head and thorax are quite dusky, and the abdomen duller red, but the pale transverse band is still distinct; the wing-pads become apparent, the members are more dusky, there is a dark red shade on the fourth and fifth abdominal joints, and, ventrally, a distinct circular dusky spot covering the last three joints.

FIG. 1.



IMMATURE STAGES OF CHINCH BUG.—a, b, eggs; c, newly-hatched larva; d, its tarsus; e, larva after first molt; f, same after second molt; g, pupa—the natural sizes indicated at sides; h, enlarged leg of perfect bug; i, tarsus of same still more enlarged; j, proboscis or beak, enlarged.—[After Riley.]

Pupa.—(Fig. 1, g.) In the pupa the coriaceous parts are brown-black, the wing-pads extend almost across the two pale abdominal joints which are now more dingy, while the general color of the abdomen is dingy gray; the body above is slightly pubescent, the members are colored as in the mature bug; the three-jointed tarsus is foreshadowed, and the dark horny spots at tip of abdomen, both above and below, are larger.

[FIG. 2.]



CHINCH BUG: Hairline underneath showing natural size. [After Riley.]

Imago.—(Fig. 2.) The perfect insect has been well described and I will append the original description:

Lygaeus leucopterus (Chinch Bug). Blackish; hemelytra white, with a black spot.

Inhabits Virginia.

Body long, blackish, with numerous hairs. Antennae, rather short hairs; second joint yellowish, longer than the third; ultimate joint rather longer than the second, thickest; thorax tinged cinereous before, with the basal edge picuous; hemelytra white, with a blackish oval spot on the lateral middle; rostrum and feet honey yellow; thighs a little dilated.

Length less than three-twentieths of an inch.

I took a single specimen on the eastern shore of Virginia.

The whiteness of the hemelytra, in which is a blackish spot strongly contrasted distinguishes this species readily (Say, Am. Entomology, I, p. 329).

The above description originally appeared in 1832 in a pamphlet entitled "Descriptions of new species of Heteropterous

Length $1\frac{1}{2}$ lines, of three-twentieths of an inch. Body black, clothed with a very fine grayish down, not distinctly visible to the naked eye; basal joint of the antennæ honey yellow; second joint of the same tipped with black; third and fourth joints, black; beak brown; wings and wing-cases white; the latter are black at their insertion, and have near the middle two short irregular black lines, and a conspicuous black marginal spot; legs dark honey yellow, terminal joint of the feet, and the claws black. (Dr. Wm. LeBaron in the *Prairie Farmer* for September, 1850, Vol. X, pp. 280, 281, where the name of *Rhyparochromus devastator* is proposed for it.)

Dr. Fitch also enumerates the following varieties of this insect:

a, immarginatus.—Basal margin of the thorax not edged with yellowish. Common.

b, dimidiatus.—Basal half of the thorax deep velvety black, anterior half grayish.

Common.

c, fulvivenosus.—The stripes on the wing-covers tawny yellow instead of black.

d, albivenosus.—Wing-covers white, without any black marks except the marginal spot. A male.

e, apterus.—Wingless and the wing-covers much shorter than the abdomen. (Fig. 3.)

f, basalis.—Basal joint of the antennæ dusky and darker than the second.

g, nigricornis.—Two first joints of the antennæ blackish.

h, femoratus.—Legs pale livid yellow, the thighs tawny red. Common.

i, rufipedis.—Legs dark tawny red or reddish brown.

To these varieties, all of which occur with us, I would add one which may be known as *melanosus*, in which the normal white of the wings is quite dusky, and contains additional black marks at base and toward tip, and in which all the members and the body except the rufous hind edge of thorax are jet black.

In addition to these varieties mentioned by Dr. Riley, an interesting form has been collected by Mr. E. A. Schwarz at Lake Worth, Fla., and by Mr. O. Heidemann at Fortress Monroe, Va. This variety is at once distinguished from other short-winged varieties by its more slender and pointed wing-pads, and by the color of the antennæ, the first three joints of which are honey yellow, while the last joint or club is nearly black. It seems also to be more thickly clothed with silvery pile, but this is probably due to the fact that the specimens studied were mounted dry, while all others which I have seen have evidently been placed in alcohol. This variety, so far as we know, has been collected on the sea-shore only.

NUMBER OF BROODS AND HIBERNATION.

For many years there existed a misconception concerning the number of broods of insects in the West. It was always understood that there was more than one brood, and some newspaper writers insisted that there are as many as five or six annual generations. Professor Riley, in the *Practical Entomologist*, Vol. I (March 26, 1866), was first to publish the definite statement that the Chinch Bug is two-brooded in northern Illinois, and Dr. Shimer the succeeding year published the same state-

[Fig. 3.]



SHORT-WINGED CHINCH BUG. [After Riley.]

ment from his own observations. This number of annual generations holds through the entire northwest and as far south, certainly, as the latitude of Saint Louis. Thomas states that there is some evidence of an occasional third brood in the extreme southern part of Illinois and in Kentucky, but that it is not sufficient to justify him in stating it as a fact, or to satisfy him of its correctness. In North Carolina there seems no question but that the second generation gave birth to still a third, which, as we are informed by Professor Atkinson of Chapel Hill, was found in a half-grown condition on Crab-grass about the 1st of October. November 17 most of the specimens found in the same locations were full-grown. This third generation probably hibernates in the adult condition.

The Chinch Bug passes the winter in the perfect state. As cold weather approaches, most of the full-grown bugs leave the hardened corn-stalks or wild grasses upon which they have been attempting to feed, and seek some convenient shelter in which to pass the winter. They collect in fence cracks, in sheds, hay stacks, straw stacks, corn-shucks, under leaves, mulching, and rubbish of all kinds upon the ground, under the loose bark of adjacent trees, in stumps and logs, under stones and clods of earth, in fact in any situation which will offer shelter. They seem to prefer dry situations. Bunches of old dead grass and weeds offer them a particularly attractive place for hibernation. Professor Atkinson writes us that the Crab-grass in North Carolina not only affords the bugs sustenance after the corn-stalks harden, but also gives them shelter for the winter, as they work their way down between the leaf-sheath and the stalk. Mr. J. O. Alwood writes us from Columbus, Ohio, that, October 26, 1887, he observed them lying torpid within the leaf-sheaths of an uncut field of Pearl Millet. During cold weather they remain torpid. On a warm, sunshiny day they will stretch their legs and begin to move about to a slight extent; but as the cold becomes severe they press back deeper into their hiding places. They can withstand the severest cold, and in fact, as with so many other hibernating insects, the more sustained the cold weather the more the insects winter successfully. An instance is related by a reliable correspondent of Dr. Thomas' in which the bugs frozen into ice were thawed and when warm manifested signs of life, crawling about as in the spring. Dr. Shimer's observations upon this point are sufficiently interesting to quote:

After the early autumn frosts they left their feeding-grounds on foot in search of winter quarters; none could be seen on the wing as at harvest time. For a winter retreat they resorted to any convenient shelter they might chance to find, as long grass, weeds, boards, pieces of wood, rails, fallen-tree leaves, etc.

In January, 1865, I next examined their condition. Those that I found in the sheaths of the corn-leaves above the snow, and had been thus exposed during the previous severe weather—when for several days the thermometer was 15° to 20° below zero—were invariably found dead without exception, and those beneath the snow

were alive. This observation was made in the common farm corn-fields, as they might be found anywhere all over the wide country, for in autumn the chinch bugs remained in great numbers in the corn-husks and under the sheaths of the blades as well as in other winter retreats. Upon various occasions, as the winter advanced, I brought in corn-husks filled with ice, inclosing the chinch bugs in the crystallized element: when the ice was thawed they were able to run, apparently unaffected by that degree of cold. It is therefore proved that these insects possess vitality sufficient to withstand the effect of a temperature below the freezing-point, and perhaps below zero, as must have been their condition in these ice-bound husks; but when in the open air, exposed to the sweeping prairie winds, 15- to 20- degrees below zero, for a long time, they succumb to the cold.

March 7, 1885, the snow having cleared off from the ground, I examined the condition of a host of these chinch bugs that had chosen for their winter covering cord-wood sticks lying on the ground, entirely surrounded by frost and ice; of these 20 per cent. were living; those that were more fortunate in their selection of winter quarters fared much better. From a single handful of leaves picked up at one grasp from beneath an apple tree I obtained 335 living and 312 dead chinch bugs; and of their lady-bird enemies that had entered the same winter quarters with them, 50 were living and 10 dead. Of these chinch bugs I placed a number in comfortable quarters in the house in a small pasteboard box, not in a stove room, together with some coleopterous insects casually gathered among the chinch bugs; after one month I found the latter all dead and the former living.

The entire month of March was rain, snow, thawing, freezing, alternately, seeming to be very uncomfortable for any living creature to remain out of doors with so poor a shelter and on top of the ground.

April 1-6, I again made repeated examinations of these chinch bugs in their winter quarters, and found about the same proportions of them living as noted on the 7th of March. At this time they wandered away on foot from their winter quarters.

Mr. G. A. Waters, in the *Farmers' Review* for October 19, 1887, gives the following interesting observation bearing on the same point:

In 1881-'82 I observed a bunch of fodder that had fallen into a ditch that the heavy rains had washed near by a shock. The fodder had been overflowed with water, which had stood over the fodder long enough for a sheet of ice to form over it. The water subsiding in a few days and some thaw occurring, I pulled the stalks out of the mud to get the ears of corn off, and in husking the ears found quite a number of chinch bugs which had been immersed for a week or more. On exposing them to the warm sun they crawled around lively.

Where they are hibernating in numbers they can often be detected more readily by their strong "bed-buggy" odor than by sight, as was pointed out by Dr. Riley. Dr. Lintner, in October, 1883, found this method of searching for them more convenient and infallible than looking for them.

Mr. Bruner calls our attention to the fact that the Osage and other brushy hedges in the West are great collectors of leaves and trash blown there by winds, and that they form exceptionally good hibernating places for the Chinch Bugs, which take advantage of them in great numbers. So great a nuisance are the hedges from this point of view, that Mr. Bruner seriously advocates their gradual removal and the substitution of a less compact division between fields.

HABITS.

With the warm days of spring the hibernating individuals issue from their winter quarters and copulate. Dr. Shimer has described a love-flight which he noticed at this time. The date was May 16, 1865, and the atmosphere was swarming with Chinch Bugs on the wing. As shown by Walsh and Riley (*Am. Ent.*, I, 173) it is probable that this occurrence was exceptional, and that the insects do not normally mate in this way; that the swarming flight was the result of a great abundance of the insects. The insect flies in spring and fall, and also somewhat in late July and early August, as the first brood becomes winged. In the fall they attain wings as the corn hardens, and their flight is then the result of a starvation impulse. In July and August the flight of the fledged individuals of the first brood is not very common, except when they occur in exceptionally great numbers. During the past season Professor Osborn observed them coupling at Ames prior to July 25, while upon this date he observed them swarming in the air, flying past his window in immense numbers and with the wind (southeast to northwest). They were first noticed shortly after 1 p. m. July 27 they were again noticed on the wing, but not in such great numbers as before. They were flying with the wind, from northwest to southeast. August 3 hosts of them were observed on the wing, while others were coupling on the ground. Others were observed coupling as late as August 16. The majority of the hibernating individuals seem, from the evidence, to copulate in the spring and without flying, but, according to Professor Riley, many of them make love in the fall preparatory to seeking winter quarters, and Mr. James O. Alwood, of Columbus, Ohio, writes that he found them copulating in a field of uncut Pearl Millet at the Ohio Agricultural Experiment Station as late as October 27, 1887.

The eggs of the Chinch Bug, which we have already described, and which are figured at Fig. 1, *a*, *b*, are laid in the spring for the first brood, and usually underground and upon the roots of plants infested. They are, however, often found above ground upon the withered sheaths near the bases of the grain stalks or often upon the blades of the leaves. They are deposited in small clusters. Professor Riley says:

A wheat plant pulled from an infested field in the spring of the year will generally reveal hundreds of these eggs attached to the roots, and at a somewhat later period the young larvæ will be found clustering on the same and looking like so many moving atoms.

The eggs are not specially small when we consider the small size of the female which lays them. Dr. Shimer says that each female lays 500, and this seems very large until we reflect that they are not all deposited at once, and that after the laying of the first few others are probably developing in the ovaries, for the process of oviposition occupies from ten days to three weeks. It has long been known that the eggs were laid in the ground, although an accurate description was much more recently

drawn up. The relative abundance of the eggs upon the stalks and upon the roots may be changed somewhat, as Dr. Thomas has pointed out, by the character of the soil. Where the soil is very damp the majority of the eggs are doubtless laid upon the stalks, whereas if the earth is dry and easily penetrated the great majority of them will be found upon the rootlets and upon the stalks beneath the ground. According to Professor Riley the eggs hatch on the average in two weeks. The young larvæ begin to take nourishment as soon as possible after hatching. They insert their beaks sometimes even before they emerge from the earth, but more often crawl up the stalk before beginning to pump. They growl with considerable rapidity and swarm over the stalk upon which they were born, walking about with ease and wandering from one stalk to another if occasion demands. As we have already shown, four molts are undergone before the insect reaches the perfect state, and generally from five to seven weeks elapse from the hatching to the final molt. Dr. Shimer's repeated observations show that at Mount Carr. Il., the imago usually appears in from fifty-seven to sixty days after the laying of the eggs, and about forty-two days from the hatching of the larvæ. By the time the majority of the insects of this first generation are full-grown, or even before, the wheat has become too hard to offer them much nourishment, or harvest time has arrived, and they begin to migrate in search of food. Neighboring corn-fields offer a more tempting diet, and in seasons of great abundance they march in numerous colonies, moving by a common impulse from the wheat to the corn. Strange to say, although the commoner form possesses wings the insect does not generally take flight, but prefers to walk along the ground. Occasionally, however, at this time they take wings and scatter. This, however, is rarer when the insects are plentiful than when they are comparatively scarce. Under no circumstances will these insects take flight to escape danger. Dr. Shimer says:

No threatening danger, however imminent, whether of being driven over by grain-reapers, wagons, or of being trodden under foot, will prompt it to use its wings to escape. I have tried all imaginable ways to induce them to fly, as by thrashing among them with bundles of rods or grass, by gathering them up and letting them fall from a height, etc., but they invariably refused entirely to use their wings in escaping from danger.

The migration takes place often, and, according to some authors, usually before the majority of the brood have attained full growth. There are always many immature individuals among a large host, and often the army is composed almost entirely of such. In fact, at these times there is apt to be a general confusion of so-called larvæ, pupæ, and adults, owing to the fact that some hibernating females oviposit much in advance of others and to the other fact, previously mentioned, that a single female takes several days or even weeks to lay all of her eggs. Professor Forbes records egg-laying presumably by hibernating individuals from the last week in May (at Decatur) until the last week in June (at Warsaw), thus making certain individuals of the first brood one

month later in development than others, in two localities not far distant (140 miles) and of about the same latitude. There are many accounts in print which are almost incredible tales of the size of these migrating hordes, and yet they are probably only too true.

Dr. Thomas states that the migration upon foot seldom exceeds 80 rods, but the winged individuals fly to much greater distances. Instance was given in the Farmers' Review for August 17, 1887, where a little patch of sweet corn grown in the midst of pine woods in northern Wisconsin, 8 miles from a cultivated crop of any kind, was badly infested with the Chinch Bug. This appearance of the bugs probably resulted from the flight thereto of mature individuals.

It naturally results from the wide difference in the method of growth of the crops that the Chinch Bugs after migrating from wheat to corn appear to be much more numerous upon the latter crop than they were upon the former, in spite of the great numbers usually killed in the act of migrating; for a single stalk of corn will be obliged to support the Chinch Bugs from a great many stalks of wheat. Moreover, the bugs swarm upon the first few rows and destroy them before invading the entire field generally. The outer rows, of course, under these circumstances are often black with bugs. The pupæ work their way down between the leaves and the stalks and there cast their skins and issue as adult insects. The leaf sheath is often thus completely filled with exuvie. The eggs for the second brood are also often if not usually deposited in this same situation—behind the sheaths of the lower leaves—and on hatching the young bugs remain there feeding and growing, and casting skins, sometimes even until the advent of cold weather and their consequent winter torpor. Others issue from these sheaths, particularly when they are especially abundant, or failing to find satisfactory locations on the outer rows take wings and fly to the center of the field and become generally scattered. They feed upon the Corn or Rye as the case may be, and upon the surrounding grasses or in the fields of Millet or Hungarian grass until the approach of fall, by which time nearly all are once more full-grown. Mr. Webster observed them at Lafayette, Ind., in August, 1887, forcing themselves down into cut stubble of *Setaria glauca* for the purpose of undergoing the last molt. He counted upwards of twenty in a single stalk. We may mention in this connection, as reported to us by Prof Osborn and also as published in the Country Gentleman for August 25, 1877, that President Chamberlain, of the Iowa Agricultural College, dug a single root of Hungarian grass at Ames, Iowa, the first week in August upon which were counted 3,025 bugs. Earth was removed with the root to the depth of 3 inches (1 inch surface), in all about 4 cubic inches.

In the north the majority of them are ready to hibernate by the time the field corn is harvested. Farther south, however, the corn grows too hard for them and considerable time before the weather is cold enough to compel them to seek winter shelter. In North Carolina, as

we have already shown, a third brood has appeared by the time the corn becomes hard, and the bugs seek the Crab-grass and there feed until ready for hibernation, finding in this grass, moreover, good shelter for the winter.

The general statements here given apply to the average Chinch Bug year in Illinois, Missouri, and the surrounding States, as the articles from which we have drawn our main facts are the results of observations made in these States. The life-history and habits of the species undoubtedly differ considerably in the more southern States, where, however, it seldom does much damage. It is very doubtful, however, that the habits differ so greatly as to admit of the correctness of the statement quoted by Fitch from the *Southern Planter* (XV, 269), that the eggs are laid in the ground in autumn where they remain through the winter and until the warmth of the ground the following year causes them to hatch! This great error (at least for the West and North) is unfortunately perpetuated by Dr. Lintner in his second report as State entomologist of New York, p. 153. There seems, in fact, every reason to suppose that this was simply a guess on the part of the editor of the *Southern Planter* without the slightest observation to substantiate it. At our request, Professor Atkinson examined a number of females found near Chapel Hill, N. C., in November, but found no evidence of mature eggs. He also searched carefully for deposited eggs with, of course, negative results. He states that Mr. Thomas S. Weaver, of Chapel Hill, has observed the bugs for the past ten years and states that they never oviposit in autumn.

In exceptional seasons and under exceptional conditions the life-history and habits will vary considerably even in the localities referred to; for example, in 1882, according to Professor Forbes's first Illinois report, there was evidently in some parts of the State but one brood, and the first young bugs were not seen before July 10. The eggs of the first brood were in some localities this season laid upon corn.

NATURAL ENEMIES AND DISEASES.

INSECT ENEMIES.—No true internal insect parasites of the Chinch Bug have yet been found. In fact very few of these smaller Heteroptera are parasitized except in the egg state. The minute Proctotrupidæ belonging to *Teleas* and *Telenomus* infest the eggs of allied species and may ultimately be found to attack the eggs of the Chinch Bug. Outside of these genera, however, we can hardly expect any aid from parasitic insects. In this connection, although it does not strictly come under this head, we may mention that in 1885 Mr. Webster found a species of *Meremis* ("hair-snakes") among the dried moltings and dead bodies of certain Chinch Bugs in a stalk of *Setaria*, which gives rise to a strong probability that one of these creatures will be found to infest the bug. Many predaceous insects destroy them, although their disgusting odor is probably more or less a protection.

Mr. Walsh in 1861 mentioned four Ladybirds, viz, the Spotted Ladybird (*Hippodamia maculata*, Fig. 4), the Trim Ladybird (*Coccinella munda*, now called *Cycloneda sanguinea*, Fig. 5), and two species of *Scymnus*. In

[Fig. 4.]



SPOTTED LADYBIRD.

[Fig. 5.]



TRIM LADYBIRD.

1882 Prof. Forbes found five species of Ladybirds (including the first two mentioned by Walsh) extremely abundant on corn (15 or 20 to a hill) which was infested by hosts of Chinch Bugs. The contents of the stomachs of a few specimens of each were examined with the following results: In three specimens of *Hippodamia maculata* no traces of Chinch Bugs were found, the food consisting of the spores of lichens, the pollen of Rag-weed, and traces of Plant-lice. One-third of the food of *Hippodamia convergens* (5 specimens examined) consisted of equal parts of Chinch Bugs and Plant-lice. In 4 specimens of *Hippodamia glacialis* 8 per cent. of the food was found to be Chinch Bugs, 18 per cent. Plant-lice, and the rest vegetation. A single specimen of *Coccinella 9-notata* had eaten no insect food. Three specimens of *Cycloneda sanguinea* had eaten some Plant-lice, but no Chinch Bugs. From these observations Professor Forbes concludes that it is possible that the Ladybirds were attracted "rather by the stores of fungi in the field than by the Chinch Bugs and Plant-lice."

The Weeping Lace-winged Fly (*Chrysopa plorabunda*, Fitch) described originally by Dr. Shimer as *Chr. Illinoensis*, has been found by Dr. Shimer to destroy the Chinch Bug. Professor Riley records the fact that the Insidious Flower Bug (*Triphleps insidiosus*, Say., Fig. 6), an insect

[Fig. 6.]



I

INSIDIOUS FLOWER-BUG. [After Riley.]

[Fig. 7.]



α

b

MANY-BANDED ROBBER. [After Riley.]

which is often found in company with the Chinch Bug and which has been mistaken for it, in reality feeds upon the pest. This is the insect which was sent to Dr. Fitch as a Chinch Bug, and which he described as *Anthrenus pseudochinche* in his second report. Professor Riley also

records the fact that he has observed the Many-banded Robber (*Milyas cinctus*, Fab., Fig. 7) in the act of preying upon the Chinch Bug, and Dr. Thomas considers this insect the most efficient of the insect enemies of the pest.

Two of Professor Riley's correspondents in 1874 stated that ants destroyed the eggs of the Chinch Bug, but the observation lacks scientific confirmation. Professor Forbes in 1882 observed a small ant (*Lasius flavus*) in extraordinary numbers in fields of Broom-corn and Sorghum, and both he and the farmer, whom he does not mention by name, made each an independent observation upon an ant which was carrying off a Chinch Bug in its jaws, but repeated dissections of ants found in such fields failed to show that they had fed on the bugs.

Professor Forbes in his 1882 report adds to the list of observed insect-enemies a common Ground-beetle—*Agonoderus pallipes* (Comma) Fabr.—of which, upon dissection, one-fifth of the total food was found to be Chinch Bugs. This is the insect figured upon Plate 1 of Bulletin 12 of the Division of Entomology and which is there stated to destroy seed corn in the ground, so that its beneficial qualities are offset by its injurious tendencies.

The evidence of Dr. Shimer, Dr. Walsh, and others, is quite sufficient to establish the fact that the Lady-birds and the Lace-winged Fly mentioned will feed upon the Chinch Bug, and Dr. Shimer's evidence in favor of the latter insect is particularly strong. His testimony as to the great abundance of the Lady-birds upon corn infested by Chinch Bugs is of course only presumptive evidence of their good work in destroying this insect. It is unquestionable, however, that the Lady-birds prefer Plant-lice to the Chinch Bugs; and in at least one instance which has been reported to us, when the Lady-birds were present upon corn in considerable numbers, and when this crop was infested by the Chinch Bug, a careful study by the observer (Mr. Lawrence Bruner) showed that the Corn Aphis was also present, and that the Lady-birds were feeding upon these latter, and did not, so far as he could see, touch the Chinch Bugs. Professor Forbes' stomach examinations previously mentioned also tend to cast discredit upon the Lady-birds as Chinch Bug destroyers.

VERTEBRATE ENEMIES.—Professor Riley published many years ago in the *Prairie Farmer* the fact that the common Quail, or Bob White (*Colinus virginianus*), was a most efficient destroyer of the Chinch Bug, and this fact has since been confirmed by other writers. Dr. Riley says:

In the winter time when hard pushed for food they must devour enormous numbers of the little pests which winter in just such situations as are frequented by the quail, and this bird should be protected from the gun of the sportsman in every State where the Chinch Bug is known to run riot.

We may add the corroborative evidence of Mr. Bruner, who combines the knowledge of an entomologist with that of an ornithologist:

Protect the birds, and above all the quails, for they destroy countless numbers of hibernating insects of various kinds that are to be picked up about the hedges and such like resorts frequented by these birds throughout the winter. Although be-

longing to the graminivorous birds the quail is essentially insectivorous, except in inclement weather, when insects are not easily obtained. In my profession as taxidermist I have dissected many different species of birds in the crops of which were contained injurious insects of various kinds—the chinch bug among others. In no other instance do I remember of the presence of this insect in the crop of a bird in so great numbers as in that of the quail. As a rule but few birds, mammals, reptiles, or rapacious insects seem to relish any of the odoriferous members of the Hemiptera or true bugs. In winter, however, this repugnance is partially overcome, and now and then even a chinch bug seems a delicate morsel when “meat” is scarce.

The Prairie Chicken, the Red-winged Black-bird, and other birds have been reported as feeding upon the Chinch Bug, and Professor Forbes mentions the fact that one Cat-bird, three Brown Thrushes, and one Meadow Lark were found in 1880 to have eaten these insects “in barely sufficient number to show that the birds have no unconquerable prejudice against them. A single House-wren, shot in 1882, had also eaten a few Chinch Bugs.” Dr. Thomas states that the common frog, according to Professor Ross and others, consumes a large number of the bugs:

Professor Ross goes so far as to express the belief that the destruction of these animals by draining their natural haunts is one reason why the chinch bug is enabled to multiply as it does in some seasons.

No account of an injurious insect is complete without an enumeration of its natural enemies and hence this summary has been given. It is plain, however, that the foes of the Chinch Bug are neither so numerous nor so active in its pursuit as are those of most injurious insects. Almost the solitary exception seems from the evidence to be the common Quail, and on this account the following short table has been compiled. It illustrates the months in which the shooting of quails is allowed in the States in which the Chinch Bug becomes or may become injurious, and it shows that while these birds are in the main tolerably well protected, certain of the States which suffer most from the Chinch Bug might with profit follow the example of Colorado or Dakota and protect the Quail altogether for a series of years.

New York.—Shooting of quails allowed from November 1 to January 1.

Maryland.—Shooting of quails allowed from November 1 to December 24. There are, however, in this State, local county laws, some of which allow the shooting as early as October 1.

Virginia.—Shooting of quails allowed west of the Blue Ridge October 15 to January 1, except in Rockbridge County, where it is allowed from October 15 to January 15; elsewhere October 15 to January 15.

Texas.—Shooting of quails allowed from October 1 to April 1.

Georgia.—Shooting of quails allowed from October 15 to April 1.

Wisconsin.—Shooting of quails allowed from November 1 to December 1. Trapping prohibited.

Michigan.—Shooting of quails allowed from November 1 to January 1. No trapping or snaring allowed for market.

Pennsylvania.—Shooting of quails allowed from October 15 to January 1.

Tennessee.—Shooting of quails allowed from October 1 to April 1 in Rutherford, Shelby, Tipton, and Fayette Counties; September 1 to February 1, in Robertson, Davidson, Lincoln, and Maury Counties; September 15 to March 1, in Montgomery and Cheatham Counties.

Missouri.—Shooting of quails allowed from October 15 to February 1. Trapping prohibited except by owner of premises.

Delaware.—Shooting of quails allowed from November 15 to January 1.

North Carolina.—Shooting of quails allowed from October 15 to April 1, except in counties of Clay, Cherokee, Graham, Henderson, Jackson, Macon, Transylvania, Tyrrell, Johnston, Jones, Ware, Onslow, Carteret, and Columbus, in which they are not protected. In Currituck County, December 1 to April 1.

Iowa.—Shooting of quails allowed from October 1 to January 1. No more than twenty-five quails to be killed in any one day by any one person.

Dakota.—Quails protected absolutely to 1890.

Illinois.—Shooting of quails allowed from November 1 to January 1. Snaring and trapping forbidden.

Ohio.—Shooting of quails allowed from November 10 to January 1. Snaring and trapping forbidden. In Fulton County quails protected to November 1, 1890.

Nebraska.—Shooting of quails allowed from October 1 to January 1. Snaring and trapping forbidden.

Indiana.—Shooting of quails allowed from October 15 to December 20.

Minnesota.—Shooting of quails allowed from September 1 to December 1. Trapping prohibited.

District of Columbia.—Shooting of quails allowed from November 1 to February 1. Trapping prohibited.

South Carolina.—Shooting of quails allowed from October 1 to March 15.

Montana.—Shooting of quails allowed from August 15 to November 15.

Arkansas.—Shooting of quails allowed from October 1 to March 1.

Colorado.—Quails protected at all times.

West Virginia.—Shooting of quails allowed from October 15 to January 1. Snaring prohibited.

Kentucky.—Shooting of quails allowed from October 15 to February 1.

Idaho.—Quails protected until September 1, 1887. (Present status of law unknown.)

New Mexico.—Shooting of quails allowed from September 1 to May 1.

Kansas.—Shooting of quails allowed from November 1 to January 1.

This compilation is drawn up in the main from an extended abstract of the State laws, published in the *American Field* for August 20, 1887, Vol. XXVIII, No. 8.

DISEASES.—The Chinch Bug has long been known to be subject to a so-called bacterial disease, which occasionally kills it off. Dr. Shimer,

in his long article in the Proceedings of the Academy of Natural Sciences of Philadelphia, gives the following account of his observations upon this disease in 1865. (Proceedings of the Academy of Natural Sciences of Philadelphia for 1867.)

July 16.—A farmer four miles from here informed me that a black coleopterous insect was destroying the chinch bugs on his farm very rapidly, and, although I found his supposition to be an error, yet I found many dying on the low creek-bottom land from the effects of some disease, while they are yet in the larvæ state—a remarkable and rare phenomenon for insects thus in such a wholesale manner to be dying without attaining their maturity, and no insect enemy or other efficient cause to be observed capable of producing this important result. * * *

On the low grounds the young chinch bugs are all dead from the disease above alluded to, and the same disease is spreading rapidly on the hills and high prairies.

The weather has been very wet since the first of July, and the barley above alluded to, which I plowed beneath the ground, did not die, but assumed a yellow, sickly appearance; in its shady, compressed, unnatural position, the ends of the heads project from beneath the furrows. The chinch bugs also remained alive for a time, but feeding on the sickly grain and shaded from the sunlight—what little we had—were attacked by disease in the same manner and about the same time as those on the low creek-bottom lands, meeting very rapidly the same fate, so that very few of them ever found their way to the neighboring corn.

July 28.—In the fields where sixty days ago I saw plenty of eggs, and forty-two days ago an abundance of young chinch bugs, the imago are beginning to develop quite plentifully. Great numbers, in all stages of their development, are dying of the prevailing disease.

August 8.—The majority of the chinch bugs yet alive are in the imago state, but they are being rapidly destroyed by the prevailing epidemic disease, more fatal to them than the plague of Asiatic cholera ever was to man, more fatal than any recorded disease among men or animals since time began. Scarcely one in a thousand of the vast hosts of young bugs observed at the middle of June yet remain alive, but plenty of dead ones may be seen everywhere, lying on the ground, covered with the common mold of decomposing animal matter, and nothing else, even when examined by the microscope. Even of those that migrated to corn-fields a few weeks ago, in such numbers as to cover the lower half of the corn-stalks, very few are to be found remaining alive; but the ground around the base of the corn-hills is almost literally covered with their moldering, decomposing dead bodies. This is a matter so common as to be observed and often spoken of by farmers. They are dead everywhere, not lying on the ground alone, but sticking to the blades and stalks of corn in great numbers, in all stages of their development, larva, pupa, and imago.

August 22.—It is almost impossible to find even a few cabinet specimens of chinch bugs alive, so that I am quite sorry that I did not secure a large supply of specimens while they were so numerous in former years; for it really appears quite probable that even cabinet specimens will be hard to secure, whereby to remember the fallen race of the unnumbered millions of former years.

September 13.—After a whole day's searching in the corn-fields, I have just been able to find two larvæ and a few imago chinch bugs, against the great numbers above alluded to in the corn about this time last year.

* * * * *

It is generally believed among entomologists that insect enemies are the most efficient means in nature for exterminating noxious insects; but in this remarkable fact in the history of insects, the great epidemic of 1865 (there can be no doubt about this being an epidemic disease, because the insects died without attaining their maturity), we find a greater enemy, the greatest insect enemy ever recorded, a dreadful "plague," that in a few days almost utterly annihilated a race of beings living in the

northern part of the valley of the Mississippi, outnumbering all the human beings that have ever lived on this planet since the morning of creation.

This disease among the chinch bugs was associated with the long-continued wet, cloudy, cold weather that prevailed during a greater portion of the period of their development, and doubtless was in a measure produced by deficient light, heat, and electricity, combined with excessive humidity of the atmosphere, whereby an imperfect physical ("bug") organization was developed. The disease was at its maximum during the moist weather that followed the cold rains of June and the first part of July. The young chinch bug spent a great portion of its time on or near the ground, where its body was colder than the atmosphere; hence, upon philosophical principles, there must have been an excessive precipitation of watery vapor in the bronchial tubes. These are the facts in the case, but in the midst of the great obscurity that envelops epidemic diseases among men, it would be only idle speculation to attempt to define the cause more definitely than the physiological laws already observed seem to indicate. At all events it will require many years of warm, dry summers, and accompanying winters of plenty of snow for protection, to reinstate the lost innumerable armies of this insect.

During the summer of 1866 the chinch bugs were very scarce in all the early spring, and up to near the harvest I was not able, with the most diligent search, to find one. At harvest I did succeed in finding a few in some localities.

Professor Forbes took up the study of the Chinch Bug Disease in August, 1882, and has published several interesting accounts of his results. A short summary was published in his first report as State Entomologist of Illinois, for the year 1882, of the long account of his studies and experiments, and it is in such shape that we reproduce it here:

On the other hand, a much more important rôle is apparently played by certain obscure parasites, not previously detected. One of these is a minute bacterium (*Micrococcus insectorum*, Burrill), infesting the alimentary canal, closely allied to the *micrococcus* found in the stomach and intestines of silk-worms, and now known to cause some of the destructive diseases of that insect. From the fact that these parasites were extremely abundant in specimens from a field where the bugs were rapidly dying, while in those from adjacent fields there were relatively very few, it was considered probable that they were related to this destruction of the bugs. This conclusion was supported by the fact that they were more abundant in old bugs than in young, while the mortality referred to evidently also chiefly affected the older individuals. It was found easy to cultivate the bacterium artificially in organic infusions, but no opportunity offered to apply it to healthy insects. Until this experiment is made and the effects carefully studied, it must remain possible that the coincidence noted was merely accidental, and of no particular significance.

Another parasite discovered is similar to that well known as a common enemy of the house fly, and belongs to the same genus (*Entomophthora*). This attacks both old and young chinch bugs, and finally embeds their bodies in a mass of mold. There is some reason to believe that this was the active agent in an immense destruction of chinch bugs which occurred in Northern Illinois in 1866, as described by Dr. Shimer, of Mount Carroll. Evidence is adduced of the possibility of artificially cultivating this parasite also, and applying it to the destruction of insects.

Since the publication of this report Professor Forbes has taken up the study of bacterial diseases of certain other insects, but there has been, so far as we are aware, no practical outcome as yet. The subject, however, has a rather hopeful look, although we should be inclined to expect more from the *Micrococcus* than from the *Entomophthora*. The evidence mentioned as to the possibility of artificially cultivating the

latter is chiefly a translation of a paper by Metschnikoff in the *Zoölogischer Anzeiger* for 1880, pp. 44-47 in which it is shown the Russian naturalist successfully induced the growth of the fungus, *Isaria destructor*, which had destroyed the celebrated *Anisoplia Austriaca*, a grain pest in Russia, in beer mash. Successful attempts were made to infest healthy larvæ with green spores taken from diseased larvæ found in the fields, but no mention is made of success, or even of experiment with the only practical substance—the beer-mash culture.

Professor Riley has always doubted the possibility of any practical success in this direction, and has pointed out the difficulties in the way. (See *American Naturalist*, November, 1883, p. 1170.)

In the introduction to the Fourth Report of the U. S. Entomological Commission (LXXXV) he makes use of the following language :

In treating of the use of yeast ferment or other fungus germs we have used essentially the language of the first edition. Time has only served to confirm us in our opinion of their practical futility in the field. The question of the practical use of these micro-organisms—these disease germs—as insecticides is a very fascinating one, and is much written about just now ; but unfortunately it proves most alluring to those who have had the least practical experience in coping with injurious insects in the field, and is much more apt to assume importance to the closet theorists than to those who, from experience, are conscious of the difficulties involved in its applicability.

It will also be apropos to quote Professor Forbes' latest utterance upon this point. He says :

Finally, *the artificial cultivation of the germs of the contagious diseases* of the chinch bug, with a view to spreading these diseases at will by means of such artificial culture. This is a theoretical remedy only, and much additional study and experiment will be required to put it on a practical basis.

WET WEATHER AND THE CHINCH BUG.

The great preponderance of evidence favors the idea, now considered well established, that wet weather is inimical to this insect. Dozens, we may almost say hundreds, of instances are on record in which the Chinch Bugs, after successfully hibernating in great numbers, have been rendered harmless by a wet spring, and in which, having laid their eggs and appeared again as the spring brood with greatly increased forces, a spell of rainy weather in early summer has caused them to vanish. Hence, it follows that dry seasons favor the increase of the pest ; and careful observation convinced Riley and others that after a season of moderate abundance (presumably therefore not a wet season) the occurrence of the bugs in destructive numbers the next season depends almost entirely upon the wetness or dryness of the ensuing spring.

The exact method in which wet weather accomplishes the destruction of the insect is a somewhat disputed point. That it is not actual submergence was pointed out by Professor Riley in his second Missouri report, and still further proven by an observation made by Hon. William McAdams and reported by Professor Forbes in his first report as

State entomologist of Illinois, and which is sufficiently interesting to quote :

In his vicinity, in Jersey County (Ills.), they (the chinch bugs) were extremely abundant in the grain early in the spring, but were all apparently swept out of the country by a long and violent storm. Some days afterwards, when the water had subsided, he noticed in pulling over the drift-wood in the river bottoms immense numbers of chinch bugs among the rubbish, most of them still alive and crawling about.

Professor Forbes also concludes that simple exposure to moisture hardly has the effect attributed to rain from experiments which he made as follows :

A number of hills infested by the bugs were successfully transplanted to boxes and variously treated with water for ten days. Some selected examples were thoroughly drenched every day, both ground and stalks; in other boxes only the ground was watered; in still others the corn was sprinkled every day, but the ground protected; and the remainder were left with only sufficient attention to keep the corn alive. During the time for which these experiments were continued, no appreciable effect whatever was produced upon the bugs infesting the stalks. Those where the corn was watered were washed down upon the ground each time, but soon dried off and climbed up the stalk. At the end of this time the bugs under observation all commenced to disappear indiscriminately, without reference to the mode in which the corn had been treated, and the experiment was thus abruptly closed. Enough was learned, however, to show that a succession of heavy daily showers for more than a week would have no appreciable effect upon these insects in that stage. The weather was warm and pleasant, and the conditions under which the experiments were carried on made it impossible to saturate the air.

So general a conclusion it seems to us is hardly warrantable from the conditions under which the experiments were made. If "the weather was warm and pleasant, and the condition under which the experiments were carried on made it impossible to saturate the air," the effect could hardly help but differ from that of a heavy shower in a corn-field, particularly from that of "a succession of heavy daily showers for more than a week," when there would be considerable cloudy weather and the atmosphere on the whole would be moist.

Professor Riley mentioned the fact that the larvæ and pupæ are more readily killed by the wet weather than the adult insects, but that the latter are also killed.

Mr. Walsh (Am. Ent. I, 175, 1869) gives the emphasis of italics to the following sentence :

In a hot, dry season chinch bugs are always the worst; in a wet season it is impossible for them to do any considerable amount of damage.

Dr. Shimer (*loc. cit.*), in his account of the epidemic, argued that it was doubtless the indirect effect of the wet weather. Dr. Thomas (Bull. 5, U. S. E. C.) expressed the opinion that the wet weather gave rise to a minute fungus which is the direct cause of the death of the insect. Professor Forbes says:

The phenomena connected with the action of parasites, which I have above described, were apparently independent of any appreciable general cause, as they were most manifest at a time when the weather had been warm, dry, and altogether un-

exceptionable for from one to two months. It is not unlikely, however, that wet weather may have the effect to stimulate the development of this parasite, either directly or indirectly—a hypothesis which will reconcile all the facts now known, as well as the conflicting explanations of them which have been hitherto put forth.

Assuming the dry weather abundance and wet weather scarcity of the Chinch Bug to be proven, Dr. Thomas in 1880 published an elaborate article in which by a comparison of the rain-fall for forty years, with the destructive appearances of the insect for the same period, he not only established a definite relation between them, but upon an admittedly somewhat uncertain septennary periodicity of rain-fall advanced the following practical conclusions :

The first and very important practical fact revealed is that we may expect at most but two chinch bug years in every seven, with the strong probability, amounting almost to a certainty, that there will not be two in succession. As heretofore stated, two successive dry years are necessary in order to develop this species in excessive numbers; the rain-fall records seldom show three dry years in succession, hence the chinch bugs are not likely to appear in injurious numbers in two successive years. The years 1851 and 1855 may, perhaps, form an exception to this rule. It is possible that the second brood of the first year may be sufficient to excite alarm, but experience has shown that they do but little injury. We may, perhaps, with safety assume, as a general rule subject to occasional exceptions, that they will not appear more than once in excessive numbers during any of the septennary periods.

If the facts shown in reference to periodicity in our rain-fall are confirmed by future investigations, and this periodicity shown to be a meteorological law of the area indicated, the practical advantage of this knowledge to our farmers is apparent to every one. By this knowledge they will be enabled to predict with a reasonable degree of certainty when to expect these insects, and can rotate their crops so as to suffer the least possible injury. This knowledge will also enable them to dispense with precautionary measures except in such years as are likely to be followed by the appearance of the bugs.

Experience has shown, and farmers are now becoming fully aware of the fact, that spring wheat and corn are the crops that chiefly aid in sustaining and developing this pest. Why corn should aid in this respect is easily seen, as it is the only extensive crop on which the second brood can feed. But why spring wheat should aid more in developing them than winter wheat is not so easily explained, but that such is the fact must be admitted. It may possibly be accounted for on the presumption that the climate of the spring wheat region is more congenial to them than that of the winter wheat area.

These facts, combined with a knowledge of the time when the dry seasons are to be expected, will enable the farmers to substitute other crops as far as possible in place of spring wheat and corn. Even if the conclusion in reference to periodicity in rain-fall should prove erroneous, the fact that two successive dry years are necessary to develop this species in excessive numbers will suffice to give notice at least one season in advance and allow the farmers to adapt their crops to the circumstances. When a dry season comes and an examination shows that the bugs are on the increase, winter wheat, wherever it is possible to do so, should be substituted for spring wheat; and oats, as far as possible, for corn.

The uncertainty in reference to temperature will, perhaps, always prevent us from predicting with certainty that a coming year will be marked by the appearance of these insects, but we may say with assurance that a wet year will not be followed by a chinch-bug year. Although this is not all we desire to know in this respect, it is, nevertheless, a very important fact and may be used to manifest advantage by our agriculturists.

It is proper to remark at this point that we have been speaking only of the rainfall over the whole area designated and the general appearance of the chinch bug over the same area.

That these insects have appeared even in injurious numbers in limited localities in intermediate years, or times different from those indicated as possible chinch-bug years, is certainly true. But, if the theory advanced is correct when applied to the area designated as a whole, it will probably prove true when applied to more limited localities. That is to say, if the meteorological record of a given locality within this area for a long series of years is examined, it will probably reveal the fact that there is a similar periodicity in the rainfall, though possibly not septennary. If this is found to be true, then the farmers of that locality will have a guide by which to rotate their crops and to take precautionary measures.

It therefore becomes important for each section to keep a record at least of the rainfall, for this will be of advantage, not only in counteracting the chinch bugs, but numerous other species, and if a periodicity is ascertained will enable the farmers to adapt their crops as far as possible to the wet or dry seasons.

In the October (1880) number of the American Entomologist (Vol. III) Dr. Thomas published practically the same article as that above quoted and stated that the bugs would probably appear over the region indicated in 1881. He advised, in consequence, the sowing of large areas of oats in 1881. Prof. Riley, in his Annual Report for 1881-'82 (p. 87), mentioned this prediction and advice, and showed that the prediction was fulfilled in part, at least, by the occurrence of the bugs in destructive numbers in several Western States. With regard to the adoption of Dr. Thomas' advice, however, he pointed out the rather curious fact that Dr. Thomas' own State (Illinois) was the only one of the large oat-producing States in which the acreage of this crop was not increased, but was somewhat diminished. Dr. Thomas in the letter of transmittal to his report for 1881 announced the fulfillment of his prediction and predicted immunity for 1882. Professor Riley (*loc. cit.*) showed that in spite of frequent rains in the spring of 1882, and in spite of the fact that 1881 was a Chinch Bug year, the bugs appeared in great numbers in parts of Illinois, Kansas, and Missouri in April and May, but that by June the reports were less alarming. The year as a whole was not marked by any extensive damage.

Upon Dr. Thomas' theory the year 1883 should not be a Chinch Bug year, and, while not desiring to encroach upon his prerogative as a seer, we are inclined to hold the same opinion concerning this season at least.

Curiously enough, an anonymous writer (J. C. H. S., of Sedgwick County, Kans.) in the Prairie Farmer for June 10, 1882, commenting upon and criticising Dr. Thomas' theory, himself predicts that 1887 would be a year of drought and consequently a Chinch Bug year—a much more daring prediction than Dr. Thomas cared to make, and which has yet been perfectly fulfilled. According to this writer's somewhat arbitrary system, 1894 will again bring a severe drought.

We introduce here, as bearing upon the rain-fall influence in the interesting North Carolina locality, the following table of temperature and

rain-fall at Chapel Hill, compiled by Professor Atkinson. It will be noticed that while the total rain-fall in both 1886 and 1887 was greater than in 1885, that during September, October, and November, 1886, and March and April, 1887, was comparatively slight, and that during June and July, 1887, high temperature occurred with the comparatively heavy rain-fall.

Table of temperature and rain-fall for spring, summer, and autumn, at Chapel Hill, N. C., for the years 1885, 1886, and 1887.

[The temperature is expressed in degrees Fahrenheit.]										
	March.	April.	May.	June.	July.	August.	September.	October.	November.	Totals to October.
1885.										
Highest temperature	75	94	90	94	100	94	92	81	71	.....
Lowest temperature	15	31	40	63	61	57	46	35	27	.....
Mean temperature	42.3	55.3	66.5	74.7	77.3	74.8	68	56.6	52.3	.....
Rain-fall (inches)	3.5	2.71	4.34	1.32	3.95	1.98	6.45	6.27	3.81	24.25
1886.										
Highest temperature	80	93	93	93	98.5	96	94	89	77	.....
Lowest temperature	24	33	46	53	62	55	52	35	24	.....
Mean temperature	49.3	59.6	67.7	78.8	76.9	75.9	75.9	58.6	49.1	.....
Rain-fall (inches)	4.97	5.99	4	6.22	7.48	9.91	2.86	1.47	2.79	41.43
1887.										
Highest temperature	83	91	93	101.8	103	92	98	.....	.....	.....
Lowest temperature	26	28	45	49.7	65.7	52	36	.....	.....	.....
Mean temperature	46.9	58.3	70.6	74.7	79.8	74.4	69	.....	.....	.....
Rain-fall (inches)	3.93	2.56	6.59	6.22	6.11	10.8	1.39	.....	.....	37.60

The following tables are published for comparative purposes. They are kindly furnished by the Chief Signal Officer, and include the official records of precipitation in Chinch Bug States for 1885, 1886, 1887:

Stations.	Precipitation.		
	1885.	1886.	1887.
Maryland:	Inches.	Inches.	Inches.
Baltimore	46.04	52.11	43.59
Virginia:			
Cape Henry	36.55	44.76	.....
Chincoteague	41.85	45.23	29.74
Lynchburgh	46.35	51.85	40.62
Norfolk	43.25	54.33	47.72
North Carolina:			
Charlotte	58.35	64.60	51.26
Hatteras	68.02	54.72	55.07
Kitty Hawk	54.78	53.98	.....
Macon, Fort	62.31	47.50	.....
Smithville (now Southport)	48.07	38.93	59.49
Wilmington	60.42	56.43	51.47
Indiana:			
Crownsville	50.11	51.65	.....
Indianapolis	39.51	39.88	33.03
Ohio:			
Cincinnati	33.94	31.35	35.08
Cleveland	39.93	37.34	35.36
Columbus	42.25	42.39	30.25
Sandusky	34.23	31.00	29.85
Toledo	33.19	32.90	32.01

¹ Closed December 31, 1886.

² Closed June 18, 1887.

³ Closed November 4, 1886.

Stations.	Precipitation.		
	1885.	1886.	Part 1887.
Illinois:	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
Cairo	31.99	37.98	26.75
Chicago	44.37	26.77	29.13
Springfield	38.61	31.69	25.15
Wisconsin:			
La Crosse	30.70	22.49	17.37
Milwaukee	32.58	31.46	30.46
Minnesota:			
Duluth	19.96	33.37	28.56
Moorehead	22.68	26.76	21.97
Saint Paul	25.33	22.89	25.85
Saint Vincent	16.58	15.04	18.47
Missouri:			
Lamar	47.05	33.48	35.72
Saint Louis	45.59	44.34	35.30
Kansas:			
Concordia	17.11	28.24	25.26
Dodge City	23.71	19.35	15.80
Leavenworth	43.64	22.25	37.05

¹ Ten months' record.² Eight months' record.

REMEDIES AND PREVENTIVES.

The remedies and preventives recommended as late as the publication of Professor Riley's 7th Rept. Ins. Mo., and there considered by him are as follows: Irrigation, burning, trapping, trampling, rolling, manuring, early sowing, mixing seed, or protecting one plant by another, preventing the migration from one field to another by upright boards or by plowed furrows or ditches, abstaining from cultivation of grains upon which the insect feeds. These remedies were also treated in detail by Dr. Thomas in Bulletin 5 of the Commission. Since this, although many changes have been rung in the agricultural newspapers on these remedies, very few entirely new ideas have been advanced. We may mention more particularly, before taking up a more detailed consideration of this question, the successful adoption of the kerosene emulsion for application at the time of migration or immediately afterwards.

Preventions.

Clean Cultivation.—With no insect more than the Chinch Bug is there greater necessity for clean cultivation. We have shown already that the insect hibernates under rubbish of all kinds, and that the grass and weeds growing in the fence corners and the leaves which accumulate there are admirable places for these insects to collect and winter. Where corn-stalks are left in the fields, and where rubbish of any kind is allowed to accumulate, there the bugs will surely be found. Therefore, the more thoroughly a field is cleaned up in the fall, the more carefully the fence corners are weeded out, and the more the bare soil is turned under the fewer will be the chances for successful hibernation.

Diversified Farming.—It follows from what we have said concerning food plants of this insect and the crops most attacked, that, from the 12734—Bull. 17—3

Chinch-bug standpoint alone, to say nothing of its other advantages, the more diversified the system of crops the better chance there will be for preventing it. A farmer who plants only Winter Wheat, Corn, and small vegetable patches, as is the practice in so many parts of the West, will always be liable to lose a large share, if not all, of his expected remuneration, from the attacks of this insect. "Diversified farming, with wheat mainly left out," is the editorial recommendation of the *Prairie Farmer* (September 17, 1887), and is certainly an exemplification of condensed wisdom. The object of the omission of Wheat, particularly Winter Wheat, is, of course, to afford as little food as possible for the first generation. Similarly the plan has been suggested of abstaining from Corn in wheat and other small-grain growing regions, with the purpose of affording as little food as possible for the second brood. The result of this plan will be that after harvest the bugs will make their way to the wild grasses, will disperse more, and vastly fewer will successfully hibernate than if there were the usual superabundant supply of food for the second generation.

Rotation of Crops.—From these same facts it also follows with self-evident clearness that crops attractive to these insects should not be sown year after year upon the same ground. This idea is so plain as to require no elaboration. Abstaining from the cultivation of grain upon which the insect feeds where, in spite of the efforts for protection elsewhere mentioned, the Chinch-bug damage is still great, will, of course, end the difficulty. Wheat, Barley, Rye, Hungarian Grass, and Millet are all important crops, but there are others such as Buckwheat, Clover, Flax, Hemp, all vegetables and fruits which could well be made to take their place for a year or two, or more, if it should become necessary. The one great result of the Chinch-bug convention held in Kansas in 1881 was the adoption of a resolution to abstain from the cultivation of Wheat, the length of time not being mentioned. As we have previously shown, large areas of Oats could be successfully grown, but in corn-growing regions most small grains must be left alone, and above all Winter-wheat and Barley. Even without concert of action among the farmers of a certain region, it will benefit the individual to abstain from Wheat and to grow Oats in preference in a year when bugs are expected, but concert of action is far preferable.

Early Sowing and Manuring.—From the evident fact that a strong, healthy, well-grown plant will better resist the attacks of the insect the deduction follows that Winter Wheat sown early upon well-manured ground and given careful cultivation will be farther advanced in the spring and will suffer less from the attacks of the bug. Heavy manuring will also cause a denser growth, which experience shows to be prejudicial to the bugs.

Rolling.—The female Chinch Bug in the spring seeks preferably friable ground in which to lay her eggs; consequently rolling the land in the fall after the crop of Winter Wheat is put in will render it less favor-

able to such egg laying. The same thing may be done with even better success after sowing Spring Wheat.

Sowing an unattractive Crop with Wheat.—Good results have been obtained, as shown by Professor Riley, by sowing 1 or 2 quarts of Flax to the acre in the spring among Fall Wheat. It is put in in early spring with a light harrowing and rolling. Its growth does not materially injure the crop. Flax and Barley have also been sown mixed upon the same ground, the seed being separated in cleaning. Similarly, corn-fields which promised a poor stand have been harrowed and sown to Buckwheat. We have already mentioned in our section on food plants the successful experiment detailed by Professor Forbes in sowing Timothy in the fall with Winter Wheat or Rye, and the same author states that in southern Illinois the sowing of Clover in spring on Winter Wheat is largely practiced "with unquestionably good effect, provided that the clover grows freely enough to shade the ground by the time the young Chinch Bug gets fairly under way." In that latitude, however, he states that the clover often makes too slow a start to effect this purpose. Professor Riley also states that it is recommended to sow 1 bushel of Winter Rye with each 12 bushels of Spring Wheat, either for the same reason or from the idea that the bugs will prefer the younger to the older grain.

Direct Winter Remedies.

Stress should be laid upon the great necessity for concerted work in winter time.

Burning.—Professor Riley says:

I can not lay too much stress on the importance of winter work in burning corn-stalks, old boards, and all kinds of grass, weeds, rubbish, and litter around grain fields, and even the leaves in the adjoining woods, in and under all of which the little pest hibernates.

In almost every locality the insects will be found to have some particularly favored hibernating place, where they can be attacked and burned out. The locality studied by Professor Atkinson in North Carolina and mentioned in a previous paragraph is a particularly good instance. There a little careful search in the fall showed the bugs preparing to hibernate in great numbers in the Crab-grass, and nothing could be easier in the winter than to burn down every spear of this grass in the vicinity of the grain fields. In the newer parts of the West, where unbroken prairie land adjoins fields of grain, it is advisable to burn over the former early every spring. Indeed this course is an absolute necessity under such conditions.

Fall Plowing and Harrowing.—After burning, if the soil can be plowed and harrowed, the chances for successful hibernation of the bugs which escape burning will be reduced to a minimum. In the same way, without burning, late fall plowing and harrowing will do much good.

Gas Lime.—Where gas lime can be easily and cheaply obtained an application of two hundred bushels to the acre will prove valuable as a fertilizer and will destroy such hibernating insects as it may reach.

Trapping.—We quote again from Professor Riley :

Much good winter work may be done also in the way of trapping the bugs. In seeking winter quarters they show a decided partiality for any flat substance, such as old boards, that do not rest too closely upon the ground. If all old boards that can be obtained are laid around the field in the fall in such manner that the larger part of the lower surface will not quite rest on the ground—which of course it will not do if the ground is in the least uneven or covered with grass—the bugs will collect under such traps and during the cold weather of winter may be scraped from them on to dry straw and burned.

He has also suggested that shocks of corn-stalks should be made at intervals throughout the field before winter sets in so as to attract the bugs, which will congregate in the shocks, where they can be burned at leisure. Almost any inflammable rubbish could be used for this purpose. In the neighborhood of sorghum mills bagasse has been used with good effect. The piles should not be too large or too compact. They should be placed during September and should be burned in December.

Trampling.—The following paragraph is from Professor Riley :

Where the custom of allowing cattle to range during the winter in the husked corn-fields, even the few Chinch Bugs which secrete in the stalks are apt to get killed by the feeding and trampling.

Direct Summer Remedies before Migration.

As is the case with so many other destructive insects, it is not until they are under full headway and in the act of doing their greatest damage that an appeal is made to the entomologist for relief, and at such times it is usually by far the most difficult thing to give any advice. A wheat field full of Chinch Bugs is as disagreeable a sight to the economic entomologist as it is to the farmer who owns it, for nothing can be done to save it. If the hand of Providence should interpose with a long-continued drenching rain relief would be gained, but in almost no other way are the crops to be saved.

Irrigation.—It was the fact just mentioned which led Professor Riley, in his 7th Report on the Insects of Missouri, to strongly recommend irrigation where it can be practiced. He says :

Irrigation, where it can be applied, and it can be in much of the territory in the vicinity of the Rocky Mountains, where the insect commits sad havoc, and with a little effort in many regions in the heart of the Mississippi Valley, is the only really available, practicable remedy, after the bugs have commenced multiplying in the spring. I wish to lay particular stress on this matter of irrigation, believing, as I do, that it is an effectual antidote against this pest, and that by overflowing a grain field for a couple of days, or by saturating the ground for as many more in the month of May, we may effectually prevent its subsequent injuries. * * * We can not, at the critical moment, expect much aid from its natural enemies, for these are few and attack it mostly in the winter time. We must, therefore, in our warfare with this pest, depend mainly on preventive measures where irrigation is impossible.

Later (Amer. Agriculturist, Dec., 1881, also Ann. Rept. as Entomologist Dept. Agr. for 1881-82, pages 88-89) he expressed himself even more explicitly upon this subject :

I have found no occasion to change my opinion as to the value and potency of irrigation as a remedy for Chinch-bug injuries, a remedy, too, that is within the reach of most farmers, for there are few who might not, with the aid of proper windmills, obtain the water requisite for irrigating their fields at the needed time, while many have natural irrigating facilities. I have repeatedly laid stress in my writings on the importance of irrigation in combating several of our worst insect enemies, and aside from its benefits in this direction, every recurrence of a drouthy year, such as the present, in large portions of the United States, convinces me of its importance as a means of guarding against failure of crops from excessive drouth. I am glad to know that many farmers, and especially small fruit-growers in the vicinity of New York, are preparing in one way or another for irrigation whenever it becomes necessary, and I was pleased to hear Dr. Hexamer, at the late meeting of the American Pomological Society, urge a general system of irrigation as the most profitable investment the cultivator can make in a climate subject to such periods of drouth as ours is known to be.

Burning.—In addition to winter burning the remedy can be used to good effect in other cases. For instance where the attack of the bugs appears to be confined to a definite portion of the field, that portion should be overlaid with straw and burned, if not too large. Another pertinent suggestion is made by Dr. Thomas in Bulletin 5, *U. S. E. C.*, and this has the indorsement of practical use by certain Illinois farmers.

If it is found at the time wheat is harvested that the bugs have not taken their departure, as is the case in the winter-wheat section, this fact may be taken advantage of to destroy a very large portion of them. If the wheat is at once thrashed and the straw scattered over the stubble and burned, it will destroy all or most of those that are there. I know of one section of southern Illinois where this has been practiced for a number of years by the German farmers with good results.

This remedy is very practical and doubtless can be used to good effect under such circumstances.

The following experiments in burning were made the past season at Ames, Iowa, by Professor Osborn, and the account is taken from his manuscript report:

On July 16 the stubble adjoining a corn field was observed to contain large numbers of bugs traveling toward corn. In the afternoon this migration was going on quite actively, and as the stubble was now quite dry it was fired with a view of destroying bugs remaining in it. Where tolerably thick, and when there was a fair breeze, it burned readily, but it was necessary to take some pains in carrying the flame along past thin spots to keep it from dying out. A considerable portion of the field, however, was successfully burned over, and the dead bodies of many bugs not completely consumed, which could easily be found on examining the burnt area, testified to the destruction of hosts of the pests. The bugs thus killed were mostly young larvæ, the majority of the adults and larger larvæ and the pupæ having already moved out. The number destroyed, however, must, I think, have well repaid the little trouble necessary to burn the stubble.

Early in August the bugs had so multiplied in a field of Hungarian grass that no further growth seemed probable, and most of the field was mown and the hay secured. A narrow strip, however, was left next the corn, the plan being to burn this as soon as bugs began passing to the corn. When the bugs started, however (August 13), the grass was not dry enough to burn except in spots. In such places as would burn, however, hosts of bugs were consumed. This strip was at once mown, and after drying a few hours another attempt made to burn it, as also on the following day; but portions were still too green to burn rapidly, and, unfortunately for the experiment,

the two or three days following were not hot and dry enough to render it fit to burn readily. A few days later, however, on a dry day with a fair breeze, most of the strip remaining unburnt was burned over, and examination showed that great numbers of young bugs remaining were destroyed. Bugs, if under ground or secreted in roots of stubble, will not be killed; hence to destroy greatest numbers, as well as to secure most rapid burning, the fire should be started in the hottest part of a dry day, when bugs in greatest number will be moving.

Prevention of Migration—direct Remedies during and after Migration

As has been so often pointed out, a great deal can be done in the way of destroying the insects at the time when they migrate from the wheat fields, towards the close of the first generation, to corn and other neighboring crops.

Ditching.—As long ago as Le Baron's first paper and as Fitch's second report the method of digging a ditch or plowing a furrow around the infested field was in vogue. If a plowed furrow be made the perpendicular side should be towards the field to be protected and the earth should be kept friable by dragging a log or brush occasionally through it, or, better still, a triangular weighted trough. The migrating bugs will fail to climb the side of the furrow and will fall back into it, where they can be covered with straw and burned. With care and activity the neighboring fields can be thus protected.

A modification of this plan appears in an unplaced newspaper cutting in our possession. It is as follows:

When they first appear, as they usually do, on the side of the corn field, and before they have entered it, cut five or six rows of the corn and clear the ground; then plow a strip of land 8 or 10 feet wide, leaving a deep furrow in the center of the same. Then take the corn stalks which were taken from the land, and place them across the dead furrow, and the trap is complete. When the bugs approach the field, they will pass in under the corn placed across the dead furrow, and, preferring the shade and moisture, remain there until the stalks become perfectly dry, when they can be put through a process of cremation that will prove effectual in destroying them. Should they first appear in the middle of a field of corn (as it not unfrequently happens they do), they can be surrounded on the foregoing plan and destroyed in the same way. This plan we consider the most practical of any that has come under our observation, and is corroborated to some extent by the experience of J. W. Martin, an observing farmer, whose experiments are given in the Osage Mission (Kans.) Journal.

Tarred Boards or Tar alone.—The plan has been adopted and is recommended in the reports of Professor Riley and others of using common fence boards—6 inches wide or less—setting them upon edge and making a barrier of them around the infested fields, care being taken to cover the lower edge so that the bugs will not crawl under them. The upper edge is spread with fresh tar, which is occasionally renewed. Vast numbers are taken out from holes dug at intervals on the hitherside of the barrier, in which the marching armies collect. Commenting upon this remedy Professor Riley says: "with a little care to keep the tar moist by renewal the boards may be dispensed with and the tar poured out of a kettle on to the ground; about a gallon is required to the rod, and it should be renewed every other day, oftener when rains prevail, until

the bugs are destroyed." According to Dr. Le Baron this method was extensively used in the central part of Illinois and especially in the vicinity of the Bloomington gas works in 1872. He saw the operation performed near Bloomington, where the tar was poured from an old tea-kettle on the ground along the exposed sides of a corn-field. This remedy, however, will seldom be used on account of its expense, except in such situations as that mentioned, where the tar can be readily and cheaply procured.

Sowing Strips of Plants distasteful to the Bugs around the Fields to be protected.—This remedy has been urged by certain authors, and the crops to be used as barriers are preferably Flax, Hemp, Clover, and Buckwheat. The effect of this will be to deter and destroy the migrating individuals and cause the death of the young ones by starvation. It is, however, not a thorough remedy, and is not to be compared with the more direct remedies which caused the almost complete destruction of the insect.

Sowing Strips of favored Food around the Fields to be protected.—A strip of Timothy, Hungarian grass, or Millet may be sown around the corn-field to good advantage with the object of entrapping the migrating bugs by plowing it under and burning the ground over when it has become filled with the migrating armies in transit. The bugs of the first generation, which are full grown, will lay their eggs by preference in this protective strip, and these will be destroyed by the plowing and burning.

Hot Water and Soap-suds.—The application of strong soap suds to the insects when gathered upon the outer rows of corn was recommended by a writer in the Southern Planter many years ago, and was also given by Dr. Fitch. Statement is made that a half gill or a gill poured upon each stalk will kill them all, and that the labor is not half so great as a single hoeing of the crop. Hot water has been recommended for a similar purpose by subsequent writers.

Kerosene Emulsion.—A new and, under certain circumstances, very efficacious remedy for the Chinch Bug was introduced when Professor Riley, in 1882, first suggested to Professor Forbes the advisability of experimenting with this substance upon this insect. Professor Forbes's first experiments were reported to this Division and the results were published in Bulletin No. 2 (February, 1883), pages 23 to 25. The following solutions were used in these experiments:

Solutions with which dilutions were made: (1) Soap-suds, 1 pound soap to 10 gallons water; (2) soap-suds, 1 pound soap to 20 gallons water; (3) potash, 1 pound to 50 gallons water.

EMULSIONS AS DILUTED.

	Per cent. of kerosene.
A. 2 parts kerosene, 1 part milk, 45 parts water (about).....	4
B. 1 part kerosene, 1 part milk, 18 parts water.....	5
C. 1 part kerosene, 1 part milk, 18 parts solution 1.....	5
D. 1 part kerosene, 1 part milk, 38 parts solution 2.....	2½
E. 1 part kerosene, 1 part milk, 38 parts water.....	2½
F. 1 part kerosene, 1 part milk, 38 parts solution 3.....	2½
G. 1 part kerosene, 1 part milk, 30 parts solution 2.....	3

All of these were efficacious. Fortunately at the time when such application is to be made, viz, just after wheat harvest, help is abundant and the work can be done at a reasonable expense. Experiments made by Professor Forbes show that a simple mechanical mixture of one part of kerosene to three of water will kill the bugs and will not injure half-grown corn if it is kept constantly agitated. But the original soap emulsion, recommended so often in the reports of this Department and made according to the formula originally proposed by Mr. Hubbard, will be much safer and will do thorough work. It will do no harm to repeat this formula :

Kerosene.....	2 gallons = 67 per cent.
Common soap, or whale-oil soap.....	$\frac{1}{2}$ pound } = 33 per cent.
Water	1 gallon }

Heat the solution of soap and add it boiling hot to the kerosene. Churn the mixture by means of a force-pump and spray-nozzle for five or ten minutes. The emulsion, if perfect, forms a cream which thickens on cooling, and should adhere without oiliness to the surface of glass. Dilute before using one part of the emulsion with nine parts of cold water. The above formula gives 3 gallons of emulsion and makes, when diluted, 30 gallons of wash.

We realize the objections to recommending anything complicated in the way of a mixture and of apparatus for applying it, and in consequence we may state, as showing that an ingenious individual who is in earnest need not be hindered by lack of a proper apparatus for applying this mixture, the experience of Maj. R. S. Tucker, of Raleigh, N. C., as published in the News and Observer, and in a special bulletin of the State Department of Agriculture, Raleigh, June 29, 1887. His letter stated in brief that having tried a number of remedies he learned of the kerosene emulsion at a time when the pest was most abundant upon the outer rows of corn. Not having any force pump or spray-nozzle with which to churn the emulsion, he whipped the mixture in a large receptacle with a bunch of twigs for ten or fifteen minutes and then applied it to his outer rows of corn with a common water-sprinkler. The results were admirable, and certainly he deserved success for his trial.

Another practical test was made by Professor Atkinson, and reported upon in the bulletin just mentioned, as follows :

Mr. William F. Stroud, of Chapel Hill, had a field of wheat which was infested with the chinch bugs. When the wheat was harvested they immediately betook themselves to the corn which was adjacent. Some of the corn stalks for 1 foot or 18 inches above ground were literally black with the mass of insects, and sometimes when they could not be seen outside they were found in great numbers between the sheath of the blade and the stalk.

[Here follows the kerosene-soap emulsion formula just given.]

I found these proportions made the liquid a little weak, and I diluted in the proportion of six parts of cold water to one of the emulsion. The application of this to

the corn, June 25, was a perfect success in killing the bugs, and the corn was examined later and was found to have sustained not the slightest injury.*

In my experiment I used a spraying apparatus, manufactured by A. H. Nixon, Dayton, Ohio, which consists of a square tank, which has a capacity of 8 gallons, with a force-pump hose and spray-nozzle attached. This machine (called the Little Gem) was placed upon a rough sled made for the purpose, which was drawn between the rows by a mule.

As the spraying apparatus produced too wide a stream to apply the liquid rapidly and effectively to the stalks of corn, I removed the spraying portion of the nozzle and used the part which produces a very narrow but strong stream (one-sixteenth of an inch in diameter). The liquid would run down the stalks and between the sheath of the blade and stalk, killing instantly the hundreds of insects with which it came in contact. The two rows were sprayed as far as the stream would reach on each side, and then the mule moved on to stop for another application. In this way the corn was gone over very rapidly. Where a force-pump can be obtained it is better to apply it with this, but the nozzle should be very small, so as to throw a very narrow stream or spray directly against the stalk. If a force-pump can not be obtained, a common watering pot, with a narrow nozzle, could be used very effectively. Several of these could be used, the operators going quite rapidly from one stalk or hill to another.

There is no reason why all should not get rid of the chinch bug on corn, for a failure to kill the bugs would arise from some fault in the application, and the application can be made cheaper than a dressing of the corn could be made with the hoe.

This application was made late in June, and Mr. Stroud reported several times later in the season that nothing more had been seen of the bugs, and Professor Atkinson, visiting the field October 17, found no Chinch Bugs in the corn-stalks where the emulsion was used, nor in the neighboring Crab-grass. Some were found, however, about 40 rods away in some late corn, but they were few in number.

Professor Osborn's experiments with kerosene emulsions, made during the summer at our request at Ames, Iowa, are reported by him as follows:

A number of trials were made with kerosene emulsion first with a view to testing its value under various conditions, and afterward for the sake of checking the damage threatened to corn.

The first trial was made July 15, the emulsion used being the common one, consisting of kerosene, soap, and water diluted to about 5 per cent. kerosene. The bugs were killed very quickly by this application, and great numbers of them could be reached, but many in particularly secreted places, in folds of leaves and under lumps of earth, escaped. Thrown on to the leaves and running down between leaf and stalk, it dislodged and killed immense numbers. Thrown against stalks where they were congregated it would quickly dislodge the mass, and while it was impossible to see whether all driven off in this way were sufficiently wet to kill them, it was certain that most of them were. This application was at the rate of about 1 gallon of emulsion or 12 gallons of the diluted mixture to 5 rows of corn for 32 rods, or what would equal 5 gallons of emulsion, 60 gallons of diluted mixture to the acre, or a cost for material of less than 60 cents per acre. In trials of the emulsion diluted to range from 2 per cent. to 7 per cent. of kerosene, less than 4 or 5 per cent. was found to be unsatisfactory, and at the lowest figure bugs even when thoroughly drenched and kept for a time in the fluid were able to recover. A mixture (about 2 per cent., pos-

* Professor Atkinson has since written that subsequent tests convinced him that one part of the emulsion to nine of water made the mixture quite strong enough.—L. O. H.

sibly a little less) which killed plant lice almost instantly, affected chinch bugs but slightly, if at all, and they afterward recovered and lived in confinement for many days.

On August 15 applied kerosene emulsion to bugs accumulating on corn, using an emulsion diluted to contain about 6 per cent. kerosene and spraying with cyclone nozzle. Great numbers of bugs could be found dead within a few minutes after application, and on the following day hosts of dead could be found on the ground around the hills treated. In places, however, the stalks had become well covered by live bugs that had moved in to fill the place of the slain.

Subsequently the farm department applied it on a larger scale, using 5 to 6 per cent. emulsion, and spraying from barrels in a wagon, one man working the force-pump and another manipulating the hose and cyclone nozzle, walking rapidly among the hills of corn and directing the spray upon the masses of bugs. This resulted in the destruction of great numbers. In this application the cyclone nozzle was found by all means most satisfactory.

I suggested its trial to some of my correspondents, and one letter received in reply is of sufficient interest to be noted :

CAMBRIDGE, IOWA, July 20, 1887.

DEAR SIR: Your most satisfactory letter received some time since. The conclusion is a success; it was instant death to the chinch bugs. But it takes so much when you want to go over five or six acres that one can not stand the expense. It could be stood to go over it once or twice if I could have got the bugs all on the corn, but they would a part stay on the corn while the rest would lie under sods and anything else that would protect them from the sun. When your letter reached us they had left the wheat (which they fully destroyed), and had gone into the corn, which they killed for ten or twelve rows in some places, and some places not so far. Then they scattered over more territory for a time, but now they have left the corn (almost), having flown away, I think. I am under obligations to you for your kindness.

Very respectfully,

J. E. WARREN.

Professor OSBORN,
Ames, Iowa.

The use of kerosene can hardly be expected to prove of value except when the bugs are massing on corn. At this time, application to an acre or two of the field next to stubble may do much to save the rest of the field. By arranging nozzles with special reference to most efficient work in corn rows, and while corn is small enough to drive a team in the field astride of one row, I think spraying can be done quite thoroughly at a cost of 30 to 40 cents per acre for material.

A cyclone nozzle, with pressure sufficient to do good work, discharges about 1 pint of liquid per minute. Adjusting three nozzles to play upon one row of corn, one each side, and one from above, and allowing teams to walk slowly 2 miles per hour, and it will take 30 gallons of liquid per acre, which, using 5 to 6 per cent. emulsion, costs about 30 cents, exclusive of labor, which for team and man an hour and a quarter would be about 40 cents more. First cost of force pump must, of course, be considered; the cost of labor on the farm, however, where the farmer uses his own team and does the managing of apparatus himself, might be counted less. By using only two nozzles or by driving faster the expense will be lessened.

BOGUS CHINCH BUGS.

Professor Riley figures and describes in his Seventh Report on the Insects of Missouri four species of Heteroptera which are frequently mistaken for the Chinch Bug and are often the cause of unnecessary alarm. We here reproduce the figures of these species. The first is the False Chinch Bug (*Nysius augustatus* Uhl., Fig. 8), which was frequently sent

to Professor Riley. It is found all over the country and occasionally damages certain crops quite seriously—grapevines, strawberries, potatoes, young apple grafts, and all cruciferous plants. It is also very fond of Purslane and, as mentioned elsewhere in this report, it is found in California congregating under *Polygonum*. It is the insect which caused the alarm in California in 1885. It was originally described by Uhler under the name above given, but was subsequently redescribed by Mr. William R. Howard as *Nysius raphani* and by Professor Riley as *Nysius destructor*. Professor Riley's description was, however, drawn up with Mr. Uhler's sanction, as the latter author at that time considered that the form described by Professor Riley might be distinct.

The Insidious Flower-bug (*Triphleps insidiosus* Say, Fig. 6) is another of these bogus Chinch Bugs. It is also a very wide-spread insect, and so far from being injurious it is one of the comparatively few insects which prey upon the Chinch Bug.

The Ash-gray Leaf-bug (*Piesma cinerea* Say, Fig. 9) is another wide-spread species which occasionally damages grape blossoms in early spring, but lives principally upon forest trees and shrubs. This species is also often mistaken for our insect.

[Fig. 9.]

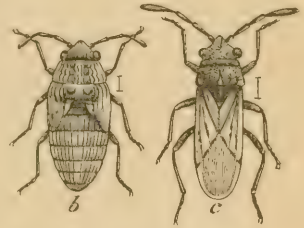
ASH-GRAY LEAF-BUG.
[After Riley.]

The Flea-like Negro-bug (*Corimelana pulicaria* Germ., Fig. 10) is the fourth.

Its appearance is more different from the Chinch Bug than any of the insects mentioned under this head, as is plainly shown by the figure. It feeds abundantly upon the fruit of the Raspberry and punctures also the stem of the Strawberry and the blossoms, leaves, and fruit-stems of the Cherry and Quince. It is also injurious to certain garden flowers and to certain weeds, among which Professor Riley mentions *Ceanothus americanus* and *Veronica peregrina*.

We may mention under this head the rather curious fact that the Striped Flea-beetle—*Systema elongata* Fab.—was found the past season in great abundance in company with Chinch Bugs in fields infested by the latter in Nebraska by Mr. Bruner. They appeared to be working upon grass and upon the wild Buckwheat. Their appearance accompanying the Chinch Bug had, of course, no especial significance, but at the same time occurring in such a way they were liable to be mistaken for another form of the Chinch Bug.

[Fig. 8.]



FALSE CHINCH BUG:—b, pupa; c, mature bug. [After Riley.]

[Fig. 10.]

FLEA-LIKE NEGRO-BUG.
[After Riley.]

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[This is simply a list of the more important of the Chinch-bug articles. No mention is made of a very large number which we have seen, but which contain nothing new or original. Every progressive step of knowledge is mentioned in some one of the articles here mentioned.]

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(Correspondent writes from Indiana. Fitch gives account of habits and injuries, past history, and nomenclature.)
1856. FITCH, ASA. *Micropus leucopterus*. Second Rep. Ins. N. Y., pp. 227-297, Plate IV, figs. 2 and 2^a.
(Gives 1783 as date when first known as insect depredator on wheat in North Carolina. Notes its occurrence at several times during next fifty years in such numbers as to nearly destroy the wheat crop. Farmers ceased to plant wheat for a couple of years as only known remedy. Alludes to drought which prevailed during period of injury, and their destruction by wet weather, 1840. First attracted attention in Western States, 1840-'44. Describes young larvæ. Mentions briefly a number of varieties. Gives history of nomenclature. Suggests spraying infested fields with water as a practical remedy.)
1857. SIGNORET, V. *Micropus leucopterus* Say. Essai monographique du Genre *Micropus*, Spinola, Ann. Soc. Ent. de France, V, 3d series, p. 31.
(A technical description from specimens received from New York and Cuba.)
1861. WALSH, B. D. Chinch Bug. Insects injurious to Vegetation in Illinois. Trans. Ill. State Agr. Soc., Vol. 4, 1859-'60, pp. 346-349.
(First notice of four Ladybird enemies of the Chinch Bug. Figures Hipp. maculata, and Coccinella munda.)
1862. HARRIS, T. W. *Rhyparochromus leucopterus*. Insects injurious to Vegetation, 3d ed., pp. 197-200, fig. 84. (See under 1852.)
1865. RILEY, C. V. The Chinch Bug. Prairie Farmer, September 19, 1865.
(Exposes the fallacy of a reported observation by Mr. D. H. Sherman in the Waukegan Gazette, to the effect that the eggs are laid upon the wheat-head.)

1866. WALSH, B. D. Chinch Bugs. *Practical Entomologist*, Vol. I, p. 95.
(Prints a clipping from *Prairie Farmer*, stating that the "bugs" had been successfully fenced out of a field by putting boards on edge around it and coating upper edge with coal-tar.)
1866. WALSH, B. D. *Micropus (Lygaeus) leucopterus*. *Pract. Ent.*, Vol. II, p. 21.
(Notices specimens of short-winged variety from Canada.)
1866. RILEY, C. V. Chinch Bug. *Pract. Ent.*, Vol. I, No. 6, p. 47.
(Exposes fallacy of a current theory that the eggs are deposited on the grain, and fields become infested from its use. Gives methods of depositing eggs and states that there are two generations in northern Illinois, and possibly three in more southern latitudes.)
1866. RILEY, C. V. The Chinch Bug. *Prairie Farmer*, Mar. 3, 1866.
(Devoted principally to remedies, recommending ditching, winter work, mixing rye or tame grass with spring wheat.)
1867. SHIMER, HENRY. *Micropus (Lygaeus) leucopterus*. *Proc. Acad. Nat. Sci. Phila.*, Vol. XIX, pp. 75-80.
(Full journal account of observations during 1864-'65 in Illinois. Conclusions as to causes of their destruction in 1865.) Page 234. (Reference to epidemic.)
1869. WALSH & RILEY. *Micropus leucopterus*. *Am. Ent.*, Vol. I, pp. 169-177, fig. 122.
(Popular inferences, past history, natural history, checks to multiplication; review of Dr. Shimer's prophecies about appearance.)
- IBID., pp. 194-199, figs. 138, 139.
(Predaceous foes of, damage done by, remedies for; summary of conclusions: (1) they hibernate in imago stage in rubbish, which should be burned; (2) early sowing in spring is an advantage; (3) compacting the soil acts as preventive; (4) heavy rains always injure or entirely destroy them.)
1869. PACKARD, A. S., JR. *Blissus leucopterus*. *Guide to the Study of Insects*, pp. 543, 544, fig. 547.
(Describes imago, life history, injuries of; epidemic diseases of 1865. Cites its occurrence in Maine and at summit of Mount Washington. Notices the theory that wet weather during breeding season is destructive to them.)
1870. RILEY, C. V. *Micropus leucopterus*. 2d Rep. State Ent. Mo., pp. 15-37, figs. 1 and 2.
(An extended account and the best yet published; discusses past history, natural history, destructive powers, heavy rains, natural enemies, amount of damage, remedies, and bogus Chinch Bugs.)
1871. GLOVER, TOWNEND. *Rhyparochromus (Micropus) leucopterus*. *Rep. Com. Agr.*, 1870, p. 89.
(Refers to observations of others as to deposition of eggs, etc.)
1872. BETHUNE, C. J. S. *Micropus leucopterus*. *Rep. Ent. Soc. Ont.*, 1871, p. 55.
(Refers to accounts of early history, habits, enemies of, natural remedies, etc.)
1872. LE BARON, WILLIAM. *Micropus leucopterus*. 2d Rep. St. Ent. Ill., 1871, pp. 142-156.
(Estimates loss from depredations current year in Illinois ten and one-half millions dollars; treats of their prevention and destruction under five heads: (1) natural enemies, (2) early sowing, (3) preventing migrations, (4) destroying by burning rubbish, (5) cease cultivating the affected crops.)
1872. GLOVER, TOWNEND. *Rhyparochromus leucopterus*. *Rep. Com. Agr.*, 1871, p. 84.
(Merely refers to its injuries in Western States and mentions salt being used as a remedy.)
1872. LE BARON, WILLIAM. Chinch Bug. *Experience of 1872*. *Prairie Farmer*, August 24.
(Believes that a sufficient number of these insects hibernate under dead leaves in the woods to perpetuate the species; also that the wet spring of 1872 destroyed large numbers of the Chinch Bugs.)

1874. GLOVER, TOWNEND. *Micropus (Rhyparochromus) leucopterus*. Rep. U. S. Com. Agr. 1872, p. 121.
(Mentions injuries in Western States to Corn, Wheat, Sorghum, etc.; three broods reported observed in Missouri.)
1874. JOHNSON, B. F. Chinch Bug. Country Gent., Vol. XXXIX, p. 661.
(Abundant in central Illinois. Stock was poisoned by eating fodder. Suggests sowing plats of noxious plants, Tobacco, Night-shade, Henbane, Stramonium, Hemp-etc., to assist in checking their ravages.)
1875. GLOVER, TOWNEND. *Micropus (Rhyparochromus) leucopterus*. Rep. Com. Agr., 1874, pp. 127, 128.
(Gives localities in Southern and Western States where reported as injurious.)
1875. RILEY, C. V. *Micropus leucopterus*. 7th Rep. State Ent. Mo., pp. 19-50; appendix, pp. 51-71, figs. 2, 3, and 4.
(Résumé of previous history, full descriptions of various stages, natural history, extended account of injuries in 1874, exhaustive discussion of preventive measures and remedies, mentions irrigation, predaceous enemies. Appendix, correspondence of farmers relating to 1874 damage.)
1875. RILEY, C. V. Locusts vs. Chinch Bugs. N. Y. Weekly Tribune, August 4, 1875.
(A letter from Lyons, France, remarking upon the abundance of Chinch Bugs and allaying fears as to great destruction by them.)
1876. UHLER, P. R. *Blissus leucopterus*. List of Hemiptera of the region west of the Mississippi River, including those collected during the Hayden explorations of 1873. Bulletin U. S. Geol. and Geog. Sur. Terr., I, second series, No. 2, p. 306.
(Mere mention, with a list of localities.)
1877. PACKARD, A. S., Jr. *Blissus leucopterus*. 9th Rep. Geol. and Geog. Sur. Terr., 1875, pp. 697-699, fig. 4 and map.
(Refers to its destructiveness in the Western States, quotes estimates of different State Entomologists, notices briefly some of the remedies.)
1878. THOMAS, CYRUS. *Blissus leucopterus*. 7th Rep. State Ent. Ill., pp. 40-71, 2 figs.
(Résumé of history, natural history, descriptions, etc. Two brooded in northern Illinois, possibly three in southern Illinois. Remedies and general discussion of same.)
1879. RILEY, C. V. Entomological Notes. The Chinch Bug. Farmers' Review (Chicago), February, 1879.
(Discusses weather influence and advances parallel between Rocky Mountain Locust and Chinch Bug. Review of life history and summary of facts from Seventh Rept. Ins. Mo. Prediction of bugs in 1879 if weather prove dry.)
1879. THOMAS, CYRUS. *Blissus leucopterus*. Bull. U. S. Ent. Com. No. 5. Ten figures, map showing distribution.
(Exhaustive résumé of present knowledge with facts concerning injuries, natural history, predaceous enemies, full discussion of preventive and remedial measures.)
1880. KANSAS STATE BOARD OF AGRICULTURE. Quarterly Report for the quarter ending June 30, 1880, Topeka, July 20, p. 61.
(An account of damage to Sorghum.)
1880. THOMAS, CYRUS. Temperature and Rainfall as affecting the Chinch Bug. Am. Ent. New series. Vol. I, pp. 240-242, with diagram.
(Condensation of his theory about periodicity of seasons of drought and their relation to appearance of this insect.)
1881. THOMAS, CYRUS. The Relation of Meteorological Conditions to Insect Development. 10th Rep. State Ent. Ill., pp. 47-59, with diagram.
(Discusses theory of Septenary Cycles of Meteorological conditions; believes it possible to predict with considerable certainty the season when Chinch Bugs will appear in injurious numbers.)
1881. RILEY, C. V. Am. Nat., October, p. 820.
(Calls attention to the verification of Prof. Cyrus Thomas's prediction that this would be a bad Chinch-Bug year.)

1881. RILEY, C. V. *Am. Agriculturist*, Nov. and Dec., 1881.
(Reviews natural history and remedies, and discusses the practicability of irrigation as a remedy.)
1882. HOWARD, L. O. *Rep. U. S. Dept. Agr.*, 1881-'82, p. 137.
(Mentions it as infesting Rice affected by "white blast.")
1882. RILEY, C. V. *Chinch Bug Notes*. *Rept. Ent., Ann. Rept. U. S. Dept. Agr.*, 1881-'82, pp. 87-89.
(Calls attention to Professor Thomas's prediction of injury during 1881 and the fact that it was partially fulfilled; discusses briefly remedies and methods of prevention.)
1882. FORBES, S. A. *Bacterium*. A parasite of the Chinch Bug. *Am. Nat.* Vol. XVI, p. 824.
(Account of discovery of parasitic disease among Chinch Bugs.)
1882. FORBES, S. A. *Blissus leucopterus*. 12th *Rep. State Ent. Ill.*, pp. 32-63, fig. 6.
(Gives full account of observations on life history, etc., for the year, insect enemies, a new insect enemy, bird enemies, account of observation on a bacterium parasite. Experiments in drenching with water under artificial conditions (not fully carried out), report of experiments with topical applications.)
1882. RILEY, C. V. *The Chinch Bug*. *Am. Agriculturist*, p. 476, 3 figs.
(General account of, habits and natural history, meteorological conditions affecting.)
1883. LINTNER, J. A. *Cir. No. 1, N. Y. St. Mus. Nat. Hist.*
(Directions for arresting Chinch Bug invasion of northern New York.)
1883. LINTNER, J. A. *The Chinch Bug in New York*. *Country Gent.*, Nov. 8, 1883.
(Directions for co-operation among farmers to prevent ravages coming year.)
1883. FORBES, S. A. *Experiments on Chinch Bug*. *U. S. Dept. Agr., Div. Ent., Bull.* No. 2.
Memoranda of experiments with kerosene emulsion and mixtures, made at the suggestion of Professor Riley; found them quite effective.
1883. FORBES, S. A. *Entomological Notes of the Season*. *State Dept. Agr., Cir.* 106, *Ill.*, crops for 1883, p. 177.
(Notes the deposition of eggs for first brood on the roots of Indian Corn.)
1883. SAUNDERS, WM. *Micropus leucopterus*. *Rep. Ent. Soc. Ont.*, pp. 59-62.
(Account of appearance in New York; quotes from Lintner.)
1883. RILEY, C. V. *Chinch Bug in New York*. *Science*, Vol. II, 1883, p. 621.
(Cites facts to show that their appearance in New York is not an invasion, but extraordinary development of the species, dependent upon climatic conditions.)
1884. RILEY, C. V. *The Chinch Bug in New York State*. *American Naturalist*, Jan., 1884, Vol. XVIII, p. 79-80.
(A reprint of an unplaced article in *Scientific American* criticising Dr. Lintner's conclusions as to reasons for alarm in northern New York.)
1884. LINTNER, J. A. 37th *Ann. Rep. N. Y. St. Mus. Nat. Hist.*, pp. 53-60.
(Not seen.)
1885. BRUNER, LAWRENCE. *Blissus leucopterus*. *Rept. Ent., Ann. Rept. Dept. Agr.*, 1884, p. 399.
(Cites an instance where large numbers disappeared immediately after a heavy rain.)
1885. RILEY, C. V. *Chinch Bug Notes*. *Rept. Ent., Ann. Rept. Dept. Agr.*, 1884, pp. 403-405.
(Refers to occurrence in New York and considers that there is no cause for alarm; predicts they will attract no further notice.)
1885. FORBES, S. A. *Ent. Calendar*. 14th *Rep. St. Ent., Ill.*, pp. 4-5.
(Notes on life history for year 1884.)
1885. LINTNER, J. A. *Blissus leucopterus*. 2nd *Rept. State Ent., N. Y.*, pp. 148-164; figs. 37-38, 39 and 40.
(Account of its occurrence in northern New York, résumé of its history, life history, remedial measures employed and recommended.)

1886. HUNT, THOMAS F. *Blissus leucopterus*. Bibliography of insects injurious to corn. Misc. Essays on Economic Ent., Ill. St. Bd. Agr., 1885.

1886. WEBSTER, F. M. *Blissus leucopterus*. Insects affecting Fall Wheat. Rept. of Ent., Ann. Rept. Dept. Agr. 1885, p. 318.

(A brief record of Chinch Bug observations during the season. Records Mermis as a possible parasite.)

1886. FORBES, S. A. Chinch Bug in Illinois. Circular of information from the office of State Entomologist.

1887. BRUNER, LAWRENCE. Notes of the season. Bull. No. 13, Div. Ent., U. S. Dept. Agr., pp. 34, 35.

(Brief notices of their appearance in Western States in 1886.)

1887. FORBES, S. A. The present condition and prospects of the Chinch Bug in Illinois for 1887-'88. Bull. No. 2 of the State Entomologist.

(Speaks of ravages for three years past, life history, food-plants, preventive remedial measures exhaustively discussed.)

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 18.

THE LIFE

AND

ENTOMOLOGICAL WORK

OF THE LATE

TOWNEND GLOVER,

FIRST ENTOMOLOGIST OF THE U. S. DEPARTMENT OF AGRICULTURE.

PREPARED, UNDER DIRECTION OF THE ENTOMOLOGIST,

BY

CHARLES RICHARDS DODGE.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1888.

Compliments of

Norman J. Colman,

Commissioner of Agriculture.



Samuel Glover

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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., December 5, 1887.

SIR: I have the honor to submit for publication Bulletin No. 18 of this division, being an account of the life and work of the late Townend Glover, my predecessor as United States Entomologist, prepared by Charles Richards Dodge. I had for some time thought of preparing a full bibliographical list of Glover's writings with a general index thereto, because of the usefulness of such a publication in the work of the Division. Such a compilation would naturally lead to some brief statement of Mr. Glover's character, and especially of his official life, and I would here acknowledge my indebtedness to Mr. Glover's widow and to his cousins in London for their kindness in furnishing information. Mr. Dodge has fortunately been willing to relieve me of a task which he is far more able to accomplish, not only because of the data he has collected, but by virtue of his long and intimate relations, both private and official, with Mr. Glover, who could certainly have had no more appreciative biographer. I trust that the bulletin may prove acceptable and useful to all interested in economic entomology.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

LETTER OF TRANSMITTAL.

BOSTON, MASS., *December 1, 1887.*

DEAR SIR: In undertaking to tell the story of Mr. Glover's life, I feel that, while it is a pleasant privilege to be able to review such interesting reminiscences of our long acquaintance as may bear upon the man and his work, the account must be necessarily imperfect and incomplete in portions from lack of important data.

The facts regarding his boyhood life are gleaned from your visits to, and correspondence with, Mr. C. G. Oates and Mr. Abram Clapham, of London, England—Mr. Oates's mother and Mr. Clapham being Mr. Glover's first cousins, the nearest English relatives who were living at the time,—and also from early personal diaries and family papers, loaned me by Mrs. Hopper.

Mrs. Glover has rendered me valuable aid by furnishing important information regarding dates, and by placing at my disposal a considerable amount of documentary evidence relating to the middle period of his life, which, with a few early letters and my own recollection of the man, and of many conversations with him touching upon his personal history, are the principal materials that have been available. I am also indebted to you for portions of the bibliography of his entomological writings, prepared by Mr. B. P. Mann, and for your kind assistance in other directions.

As the subject of this sketch was a man of great individuality, I have thought it best to present the main facts of his life in such manner as will more fully bring out his personal attributes and peculiarities, and leave the treatment of his entomological and museum work, or that which bears directly on his connection with the Department of Agriculture, to special chapters. Some of the extracts or incidents may seem trivial, but the make-up of the man embodies such diversity of talent, and at the same time presents such originality, that it has seemed best to use that material which will best show him forth as he was.

I am yours, respectfully,

CHARLES RICHARDS DODGE.

Prof. CHARLES V. RILEY,

Entomologist, U. S. Department of Agriculture.

THE LIFE OF TOWNEND GLOVER.

Prof. Townend Glover, the first entomologist of the United States Department of Agriculture, was born at Rio de Janeiro, February 20, 1813. His paternal grandfather was Mr. Samuel Glover, a merchant of Leeds, England. His father, Mr. Henry Glover, an only son (though there were several daughters) married Miss Mary Townend, of Leaming Lane, Yorkshire, and was engaged in commercial pursuits at Rio de Janeiro when Townend Glover was born. His mother dying, after a few days illness, when he was about six weeks old, he was sent to his relatives in England; and, upon the death of his father, which occurred some six years later, he was taken in charge of by his paternal grandmother and maiden aunt in Leeds. Here his education began, as he was placed in a private school of high reputation, of which the Rev. Mr. Holmes was preceptor.

By nature the boy Townend was of a reserved disposition, making few close friendships outside the immediate circle of his own family. He was, nevertheless, abounding in high animal spirits, possessed of a strong sense of fun and humor, which always made him an agreeable and entertaining companion to those with whom he was wont to associate. In his studies at school he showed a fair degree of aptness, and being endowed with good abilities he is said to have acquitted himself with unflinching credit, and without any special effort on his part.

Even in boyhood his love for drawing showed itself, chiefly in caricature of the people about him, admirably done at that early period, it is said, his efforts sometimes bringing the youthful artist into trouble.

The beginning of his love for entomology dates back to these early school-boy days, at which time, in company with the one congenial and intimate friend of his boyhood, a lad with similar tastes, he was already interested in making a collection of insects, which, it is said, he prepared and mounted with skill. As a boy he was very clever with his hands in anything requiring care and nicety, and was singularly quick and apt. And not only was he drawn towards the insect world, but natural history in all its branches, and even botany, had an early and peculiar fascination for him. Upon leaving school, we are told that young Glover was prevailed upon by his friends to enter the warehouse of a firm of Leeds merchants, with a view to acquiring a knowledge of the woolen goods

trade. Mr. Glover alludes to this in his diary (March 16, 1834) in characteristic language, as follows:

Mr. C. this evening gave me my indentures of apprenticeship to Thompson, Scarf & Co., by which I find that £300 of my money is gone forever, merely to learn the "art and mystery" of a stuff merchant, a mystery I hope never to practice.

What other plans for his future may have been made for him, or were entertained by himself at that time, are not known, though his aunt was once very desirous that he should study for the ministry. In after-life he frequently referred to this with satirical allusions to having been cut out for the clergy; and in a letter written to friends in England many years after coming to America it is amusing to find a joking reference to his clerical education. In his commercial life, with its exacting routine, though utterly at variance with every instinct of his nature, he fulfilled the duties which the position entailed upon him conscientiously and with assiduity as long as he continued in it. The early discipline did him no harm, if, indeed, it did not fit him for the life of most exacting routine of his later years, to which, though self-imposed, he gave the best years of his existence.

But there suddenly came an end to his commercial education, for at the age of twenty-one, or as soon as he had reached his majority, he shook himself free at once and forever from the trammels of business life.

His father had bequeathed him an ample fortune, but, as Mr. Glover once gave the story to the writer, through the perfidy of his father's partners in business, or others associated with him in Rio, the fortune had been dissipated, save a portion which, unknown to Mr. Glover, until he had reached his majority, was reserved in trust by relatives in England. Mr. Glover not only thought that he had been cheated out of his patrimony, but on at least one occasion has intimated the suspicion that his father's death had occurred from other than natural causes. Some weeks after arriving at his majority he received the small fortune held for him by relatives in Leeds, and having meantime fitted himself for going abroad by the study of German, he began active preparations for his journey. To one who has known Mr. Glover intimately in later life his diary kept at this period is most interesting, as showing, even at the age of twenty-one, so many of those traits of character or individualisms, if the term may be used, which so strongly marked the mature man. Indifference to country or home, distrust of mankind and of the motives of people about him, self-reliance and a wish to be his own master, and at the same time frequent evidences of the good influences by which he had been surrounded in the family circle in which he was reared, appear on many pages. Some are so striking I can not forbear making a few brief extracts.

During a short visit to Burneston, in April, 1834, he wrote:

Sauntered about all day, reading Tam O'Shanter; begin to think a country life would be very tiresome. Could manage to spend some months very pleasantly in the

country, provided I had books, paint box, horse, gun, flute, etc., not forgetting a pleasant friend, without which a man might be tempted to shoot or drown himself for very ennui.

The entry for the next day is confined to three short lines :

What with teasing the servant about her lover, plaguing the cat, and gossiping with the villagers, managed with difficulty to live the day out.

Evidence of a restless nature, abhorring idleness.

Having decided to indulge his taste for artist life and at the same time see something of the world, on the 19th of April, 1834, he quitted Leeds and started for Munich, with a view of putting himself upon a systematic course of study in different branches of painting. Regarding his leave-taking he says :

Miss G. [his aunt] cried most prodigiously, as if I should never return home—home did I say? I forgot that I have no home and that for the future I must consider the world as my home, or, rather, make a home wherever I am. I leave some few people in Leeds whom I shall regret to lose, but on the whole I like my prospects very much.

He spent nearly a month en route to Munich, stopping at Hamburg, Hanover, Gotha, and many other places, and arriving on the 14th of May. Here he began study at once, though at first he confined himself to the study of the German language under one Dr. Caffish, and it was not until a month later that he had made arrangements with the artist Mattenheimer, "the inspector of the gallery," to give him lessons in fruit and flower painting in oil.

Under date of June 19, 1834, he writes :

Took my first lesson in flower drawing and like it very much; he (Mattenheimer) says he sees that I have talent, from my drawings, and that in a little time I shall paint very well—flattery to make me learn—but don't care; if it pleases me I intend to continue it till I paint tolerably.

A week later, this :

For the first time handled palette and brushes and daubed a little in oil painting. Mightily pleased to have advanced so far; don't intend to say anything about it to my friends in Leeds, or they will expect miracles of me.

A few days after this his master has been trying to persuade him to be an artist. "Will not, though, whatever he says," closes the entry.

Regarding his art work at this time it has been said of him that still-life and natural history subjects were his special delight, whether he painted in water colors or oils; and so successful was he in what he undertook in this way that with some who were well acquainted with his work, it was a source of regret that he did not make painting the serious study of his life. Notwithstanding this statement, it is not likely that Mr. Glover would ever have made a great artist in the sense of producing strong, original *pictures*. From a study of examples of his best efforts produced both in Europe and in America (oils and water colors), it is very evident that he was strongest in the direction of illustrative work, or close studies, where great detail and accuracy of delineation were absolutely essential. He was at his best in still-life, therefore, and especially in the painting of fruits, flowers, and the lesser animal life.

A number of his works in oil, which he brought to Washington, were only copies from the productions of his masters or other painters, and should not be taken as standards of his ability.

His water color paintings of flowers and insects and a few natural history objects, are most exquisite examples of artistic illustration, and are drawn to the life, showing the expenditure of a vast amount of labor and patience, and giving assurance in the artist of a fair eye for color. As a rule they are painted with little attention to modeling, the color being laid on heavily, stippled and frequently lacking in transparency, and without attempt at composition in the sense of making pictures of them. But they are very realistic and sometimes quite decorative. Many of his early drawings of the Florida insects are as exquisitely finished, though with his later originals he took less pains. When Margaret Fuller first saw some of the flower paintings she would hardly believe that they had not been done under the microscope, so delicate was the work. Whether or not his extreme shortsightedness made it difficult for him to paint in any other manner, it is impossible to say, however well adapted to the labors of his after life this special kind of work may have been. He could not have painted broadly had he desired to do so, for his almost microscopic vision saw everything in the minutest detail. This explains, too, why his after engravings of insects, particularly of *larvæ*, lack in action.

After finishing his journeyings in Europe and having turned his back upon Munich, the study of art was still an absorbing interest with him. On his return to England he took up his abode at Leeds for a short time, and, in a room set apart for the purpose of a studio, and surrounded by pets of every conceivable description, he continued to paint with assiduity. And it is pleasant to learn that his love of natural history shared equally with his love of art. Many delightful reminiscences of the young painter-naturalist (who was now about twenty-three years old), are recalled by those who knew him at this time, all indicating the manner of life which he afterwards followed. Mr. Oates thus writes of him in a memorial sent to Professor Riley :

He would sit before his easel with a favorite lizard nestled in his breast, his coat pockets tenanted by snakes, and a blackbird perched upon his shoulder, whilst hanging on the walls of his apartment might be seen some tiny gauze cages, daintily constructed for the reception of tame spiders, which were periodically supplied with flies. There were also in the room a variety of other birds and such quadrupeds as mice, rats, and guineapigs, all pets in a greater or less degree. Glover's early school friend, previously referred to, still living at Whitby in Yorkshire, particularly recollects visiting him in this apartment on one occasion when he was painting a bunch of grapes, his blackbird as usual upon his shoulder. Glover had just completed the painting of the grapes, when the fancy seized him to add a fly, as though it had alighted on the fruit. This he did, and had scarcely withdrawn his hand from the work, when the blackbird darted from its master's shoulder and pecked lustily at the phantom fly. About this time Glover had begun to give some attention to copper-plate engraving, and also carved in wood. He sustained a great sorrow in the death of a little girl, the child of a first cousin, who was devotedly attached to him and for whose amusement he

never wearied of exerting himself, for his affections once roused were acutely sensitive and tender. Glover was possessed of great physical activity, and though not skilled in horsemanship was fond of riding. On one occasion, it is stated, that whilst riding on a friend's horse, which proved restive, he was thrown violently to the pavement, and his head striking the curbstone, he sustained a fracture of the skull. For some time his life remained in jeopardy, and though to all appearance he ultimately recovered from the effects of the accident, it has been suggested that the injury then received told on him in later years and led to the somewhat premature failure of his powers.

Professor Glover has more than once stated to the writer that the scar upon the side of his head was made by the bursting of a gun barrel and Mrs. Glover verifies the statement. It occurred, too, before he went to Munich, for there is a reference to his fractured skull in his journal. However the injury was inflicted, I can not think the suggestion made above has any weight, as Mr. Glover's peculiar and irregular mode of life in after years, without recreation, and his prolonged ill-health for several years in a trying southern climate, were sufficient causes for his breaking down before reaching three score and ten.

Whether or no Mr. Glover returned to Munich again can not be stated from any written records. During a few weeks of his first summer in Germany (1834), he made an extended pedestrian tour through the Tyrol with his German teacher by way of vacation and to learn the language. Some of his pencil sketches made in Tyrol are dated 1836, but as he sailed for America June 24 of that year, he could only have made a flying visit to Germany, if at all. He decided to visit the United States through the representations of some relatives, young men who settled in America about this time, though he did not at first entertain the idea of making it a permanent abiding place. His roving disposition prompting a period of adventure and sight-seeing before settling anywhere, he at first spent his time in travel.

This was a turning point in his life. The fine, open scenery, the lakes and vast rivers of the United States appeared to exercise a powerful influence on his impressionable nature and led to his making it his home. For several years after coming to the New World he roamed at leisure through different parts of the country, and particularly in the South, making New Rochelle his headquarters, for there are records of his having remained in New Rochelle, near New York, at various times during the years 1836 to 1839. He was in New Rochelle August, 1836, and in that month started on a journey through New York State, thence West and South, the close of the year finding him in Louisiana and Texas. In 1837 he was again traveling about through the picturesque portions of New York State, and early in 1838 was once more South, visiting the Carolinas, Georgia, and adjacent States.

Mrs. Glover tells me that he finally settled in New Rochelle in the spring of 1838, and here his dog and gun, or rod and boat, were almost constant companions; his boat, which he built and was very much

attached to, demanding the greater part of his time. When it was launched there were some lines written commencing :

To Townend we drink, that lad of much fun,
So deeply in love with his dog and his gun.

A volume might be filled with the stories Mr. Glover has told me of his life at this period. He was "hail fellow, well met," everywhere, having all the friends he desired (sometimes too many, doubtless), and devoting himself to pleasure.

It was during a brief visit to Fishkill that Mr. Glover first met Miss Sarah T. Byrnes, an estimable young lady, and the daughter of Joseph T. Byrnes, a gentleman of prominence, who owned a large estate lying upon the banks of the Hudson. An attachment having sprung up between them, they were married in September, 1840, in New Rochelle, and in the following spring went to live in Fishkill-on-the-Hudson (then known as Fishkill Landing), Mrs. Glover's native place.

During the five years which followed Mr. Glover chiefly interested himself in floriculture, in natural history studies, and taxidermy, a large case of the native birds of Dutchess County, N. Y., shot and prepared by him, still remaining in excellent condition, evidence of his taste and skill in this direction. He also employed a part of his time in art, as Mrs. Glover particularly remembers two large oil paintings, one of fruit, the other of flowers, which were produced at this time, and subsequently presented to relatives in England.

In the spring of 1846, in company with his wife, Mr. Glover visited his relations in England, remaining until fall. Upon his return he went to live upon his own place, which he had purchased from the Byrnes estate, and a more romantic and beautiful spot he could hardly have chosen. Lying upon the crest of a gentle slope, in sight of Storm King, the surrounding country broken into majestic hills and deep vales, at a point where the noble river makes a bend to the left and is joined by the creek which swept at the foot of his garden, the view was one of surpassing loveliness. I first saw it through the yellow haze of a bright October day and while viewing scenes which had been so familiar to him—the orchard that he had planted, the garden plot where he spent so much of his time, and the rocky creek, upon the banks of which he had had so many piscatorial triumphs, for he was an expert disciple of Walton—the wonder came how he could have left it all, and become satisfied with the hum-drum life into which he drifted in later years. In this beautiful place, on his return from England, he began in earnest the life of a country gentleman, busying himself with the planting and care of fruit and ornamental trees, and with his garden, which was noted for its fine flowers and vegetables. He also paid considerable attention to the cultivation of small fruits, all the leading varieties of which were tested by him.

Mr. Glover visited England again in the fall of 1849, and at this time spent some days at Walton Hall, in Wakefield. Mr. Oates states that while staying on one occasion with a cousin at Scarborough, with whom

he was on intimate terms, he chanced to meet Charles Waterton, who was stopping at the same place, and the two cousins subsequently became for a short time the guests of the veteran naturalist at Walton Hall. Upon his visit in 1849, Waterton presented Glover with several of his works, the "Wanderings," now in the possession of Mr. William H. Edwards, containing the naturalist's autograph.

During this period of Mr. Glover's life, that is, the latter part of the forties, he made the acquaintance of Mr. A. J. Downing, and through the intimacy which followed he became deeply interested in pomology, his enthusiasm prompting him to devote himself to it for a time. Then came the desire to do something of practical and lasting value that might be appreciated beyond the narrow limits of the little world in which he moved. The scheme of illustrating American pomology by a series of perfect fac-similes, with special regard to the changes produced by differences of soils and climates, was planned and entered upon. At first he experimented to find the best composition of which to make his models, and practiced with the laying on of color to get the most natural effects. His first efforts are said to have been very crude, but he worked persistently until success was attained, and then he began the collection. Two rooms were set apart for a workshop, materials purchased in quantity, and the work was pushed as rapidly as possible during the fruit season, and continued for several years.

The formation of this collection, without doubt, had more to do with altering the course of his after life than has been supposed, for through it the ten years of rural quiet at Fishkill were followed by a period of roaming again. At various times between 1849 and 1852 his collection of fruits were exhibited at State fairs and elsewhere, a number of cups and medals having been given him as prizes. They were once or twice exhibited in Albany, once in 1851 at the exhibition of the New York State Agricultural Society, and subsequently at a meeting or exhibition of the American Institute in New York, the collection at this time being quite large. Correspondence in my possession shows that in 1852 he arranged for an exhibition in Horticultural Hall, Boston, though I do not know that the fruits were ever exhibited there, though they were exhibited in several other places.

Mr. Glover had now made considerable reputation as a pomologist. He was invited to act as a judge at the New York State and other fairs, and wrote for the American Agriculturist on pomological subjects. A letter from the late Marshall P. Wilder, bearing date November 7, 1851, makes mention of a "beautiful and correct cast of a Louise Bonne de Jersey pear," recently brought to his notice, the letter closing with an offer to send him some specimens of new fruits.

The attention that these models had attracted and the commendations Mr. Glover had received for his collection led him, in the winter of 1853-'54, to take them to Washington for exhibition and possible sale. This was about the time that the new Bureau of Agriculture was established in the United States Patent Office, and Mr. Glover very

soon became connected with it. His commission bears date June 14, 1854, and his appointment was made "for collecting statistics and other information on seeds, fruits, and insects in the United States." A small cabinet was at once begun in the single room then devoted to the Bureau of Agriculture, the fruit models forming no small part of the exhibit.

The collection of fruit models now comprised some 2,000 specimens, the matrices being also preserved and numbered, that duplicates might be made if desired. "It has taken \$3,000 in cash and six years of unremitting toil" to produce them, is Mr. Glover's written testimony about this time concerning the collection.

Mr. Glover's name is not mentioned in any of the official reports of the Commissioner of Patents. By inference, however, we know that he held the dual position of entomologist and special agent, his duties necessitating travel upon various missions bearing upon the agricultural interests of the country, through the Southern States mainly, and at one time into South America. Charles Mason was Commissioner of Patents at this time, the chief clerk in charge of the Bureau being D. J. Browne, of New Hampshire.

In 1854 Mr. Glover studied in the field the insects affecting various crops, the summer months being spent in South Carolina investigating the grape insects and the insects injurious to cotton. In 1855 he was ordered to Florida, where he occupied himself during the entire season of five or six months in studying the habits of various insects and in investigations upon the insect enemies of cotton. In a private letter he alludes to this summer having been spent most pleasantly "with alligators, mosquitoes, and red bugs." It may be worthy of note that nearly all the drawings which subsequently appeared in his twenty-two plates of the cotton insects were made at this time in and about Tallahassee, though his field of observation extended from Columbia, S. C., southward. It was in this year, too, that he first met the one congenial friend and companion of his Florida experiences, a worthy gentleman, Mr. Henry Wells, the friendship lasting through life. Mr. Wells was always dignified with the pseudonym "Alligator" to the last of their acquaintance, Mr. Glover's correspondent appellation being "Old June Bug."

The experiences of this season also inspired the Florida litany, which Mr. Glover was wont to repeat upon occasions with great satisfaction. He was frequently asked for copies of the lines, and he always returned an emphatic "no," for he never would allow original verse of this description to get out of his possession, at least when he could help it. Here is the litany as jotted down by me during a chance recital not long after a refusal to make a copy of the lines:

From red-bugs and bed-bugs, from sand-flies and land-flies,
 Mosquitoes, gallinippers, and fleas,
 From hog-ticks and dog-ticks, from hen-lice and men-lice,
 We pray thee, good Lord, give us ease:
 And all the congregation shall *scratch* and say Amen.

In the winter of 1856-'57 he was ordered to British Guiana and Venezuela to take charge of an expedition having for its object the restocking of the Louisiana sugar plantations, the native cane having deteriorated to a degree affecting the sugar interest. An appropriation of \$10,000 having been granted for the purpose, the bark *Release*, with a competent crew, was placed at the disposal of the Patent Office, and Mr. Glover, as the Government agent, placed in charge of the expedition. He was in every way

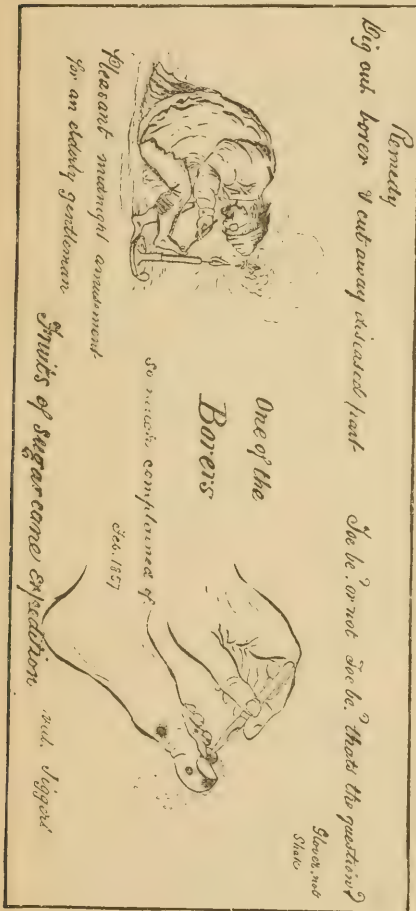


FIG. 2.

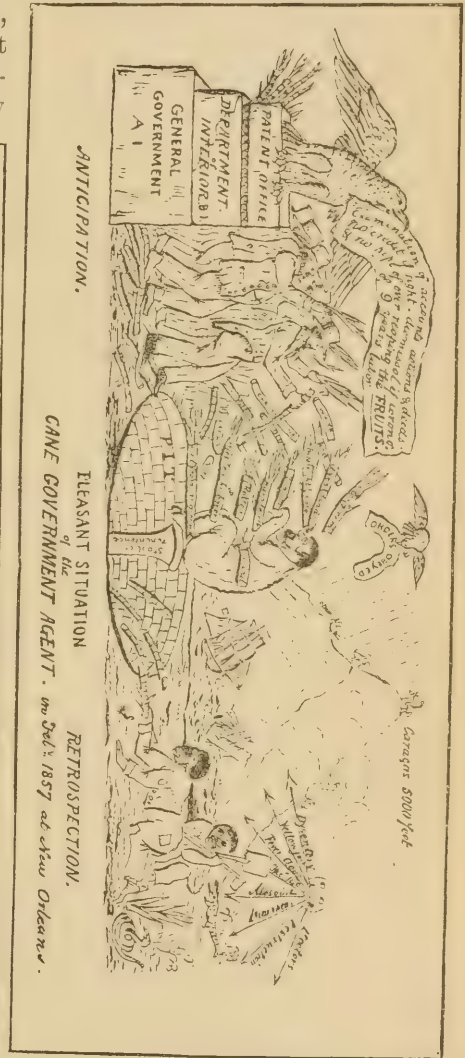


FIG. 1.

successful, bringing a large cargo of cane to New Orleans, though he was attacked with fever very soon after, the result of his exposure in a malarious country, and for a time was very ill. A couple of caricatures of himself made at the time are interesting. (See Figs. 1 and 2.)

About the middle of August, 1857, he was ordered to Mississippi, where the remainder of the season was spent in visiting cotton plantations in different portions of the State. It was a hard season for him, as he was sick during the greater portion of the time, often being confined to his bed. An entry in his journal October 6 is characteristic. "Quarrel between doctors, so I have to dismiss one, and the other says it is no use to attend. Saved my life by it."

It is worthy of mention that at this time his observations were not confined to entomology alone, but to all branches of natural history. Indeed, he let nothing new escape him in any field of experience, his "mems." indicating observations upon insects other than affecting cotton, cotton diseases, soils and earths, vegetation, birds, animals, reptiles, Indian mounds, and even human nature.

The year 1858 marks the period of his investigations upon orange insects, he having been ordered to Florida in the latter part of April, where he remained throughout the season. It was an eventful year, inasmuch as it was marked by events which later on led to his severing his connection with the Patent Office, and beginning his work on entomology.

He now had made the acquaintance of Baron Osten Sacken, Dr. Morris, Mr. Uhler, and other of the earlier American entomological authorities, and had become a member of the Washington Naturalists' Club. In the records of his life at this period are frequent occurrences of the names of Professors Henry, Baird, Girard, Drs. Hayden, Kennicott, Clemens, Forman, Meek, Messrs. Ulke, Cooper, and others, with allusions to prominent Senators and Congressmen of the day. It was almost at the beginning of this year, too, that the first evidences of friction between himself and his immediate superior officer became apparent. He was working at this time upon the plates of his Cotton Insects and Diseases, besides engraving special plates for publication in the annual volume, under the direction of his superior, D. J. Browne.

In January we find such brief entries as the following: "Blow up with B. about article on plows."—"At work etching tea-plant."—"Writing reply to weevil article."—"Row about sorghum."

In February: "Heard at Browne's about Kennicott wanting Fitch here."—"Bothering about bees for Browne. Made sketch; not right."—"Etching and fussing about the bee plate for B., as he don't know what he wants."—"Evening at B.'s: *he will write* all my reports himself, and makes an ass of himself and a fool of me. Don't and won't acknowledge it, as I have never written a word of what he says, and he has not looked at my report yet."

In March: "Evening at Girard's, who advises me to stay, although D. J. B. *will* make a false report of me."—"Another row with D. J. B. He must be crazy."

In April: "Browne at my room, evening, grumbling about Dr. Higgins trying to supersede him; he has got an idea (Heaven knows why)

that I am as great a naturalist as Audubon! That Audubon had Bachman to write his articles, and I have (Lord save the mark!) Browne!—"Still waiting orders. Smithsonian—no cans, no bottles, no tins, no nothin'".—"Spoke to Shugart, who will see Commissioner about my report."—"Off to Florida," etc.

Through May and June he was hard at work in the field observing, sketching, and experimenting with solutions for the destruction of the orange insects. An extract from an official letter to him, signed by his superior officer and bearing date June 23, is interesting at this point. After referring to what has been done and the difficulties in the way it says: "But a more effectual remedy would seem to consist in covering the entire tree with some glutinous fluid, which would close up the apertures of the shells and prevent escape of the perfect insects. Blood has been suggested as being both feasible and economical, preserved by salting, and made sufficiently dilute with water to be readily applied with a syringe. Near the regions where the orange tree flourishes in Florida the alligator is found in great numbers. It is well known that this reptile abounds in blood, which could readily be taken in the winter, when it is in an inactive state. This blood could be preserved in casks, etc.

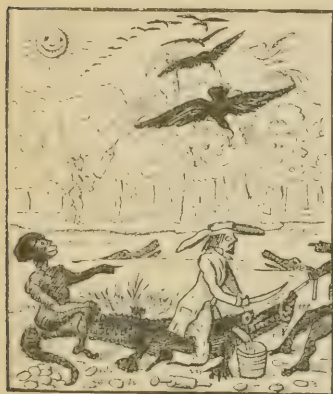
July 3, this entry: "Killed alligator. After stabbing him in the neck and dividing vertebrae he still lived several hours. Not one pint of blood in its whole carcass, and nearly 5 feet long—one quart to 10 feet; 100 alligators to 25 gallons. Absurd!" As no after mention is made of this proposed remedy, and there is no reference to it in Mr. Glover's published report, it doubtless did not amount to anything.

A year after, however, when Mr. Glover had left the office, a series of articles against D. J. B. appeared in a Washington paper, signed with a *nom de plume*, and among other things this matter was touched upon. While Mr. Glover would never admit that he had written the articles, he never denied their authorship. They bear his unmistakable ear-marks, however, and were preserved by him with other personal writings. As an example of rich satire this one extract on the alligator question is presented:

I have been credibly informed by a gentleman who has had some practical experience in combatting his (the alligator's) obstinate disposition to shuffle off this mortal coil, that, being an animal of warm and generous blood and of a highly excitable temperament, he will yield the almost fabulous amount of *one pint* of the much desired crimson fluid. One of 10 feet then will give 2 pints, and 100 of that length somewhere in the neighborhood of 20 gallons. Two hundred negroes might possibly capture 100 alligators in a day, one being necessary to hold the head and another the tail, whilst the surgical operator undertakes the pleasing task of relieving him of his claret. Supposing, then, each negro to measure only 5 feet in height, the account would stand as follows: 1,000 feet of negroes to capture and demolish 1,000 feet of alligators, the produce of which would be 20 gallons of the coccus exterminating blood. Estimating, then, the hire of each darkey at \$1 a day, making \$200 for 20 gallons of sanguinary fluid, which might effectually syringe twenty orange trees in a grove, and, without mentioning the fees of the saurian phlebotomist, you have one of the most astounding

examples of economy in labor that has ever yet soothed and flattered the *otium cum dignitate* of a labor-shirking and a labor-saving world. Wonderful D. J. B.! Confiding ex-Commissioner! Happy and grateful Floridians!"

A caricature on this theme, drawn by Mr. Glover in 1859, with himself portrayed as the "saurian phlebotomist," is presented herewith (Fig. 3).



Orders the U.S. Entomologist to phlebotomise alligators scientifically & to syringe Orange trees with the blood thereof to kill the scale insect & complaineth because said orders cannot be executed

FIG. 3.

During the remainder of the year 1858, while in Florida, he was industriously employed with field observations, visiting plantations and groves in different parts of the State, syringing whole groves of orange trees, engraving his plates and writing his notes, besides other work for the Department, such as collecting live oak acorns, etc. He was sick much of the time, and complains sorely of mosquitoes and similar insect pests. A characteristic entry in his journal is as follows:

"Etching, itching, and scratching as usual from 8 to 4; scratching with pen from 8 till 12, and with finger nails continually."

He severed his connection with the office very early in 1859. His final report is published in the volume for 1858, and in the Commissioner's report in the same volume the statement is made that "the Entomologist has brought his labors to a close." The principal reason for his leaving the service was his inability to get along with the chief clerk, whom he always considered of small ability, and a man who shone only by borrowed light.

The appreciation of his efforts by others always gave Mr. Glover great satisfaction. A little glimpse of this side of his nature, in statements made confidentially to his cousin (Mr. Clapham), I trust will not be considered out of place here:

I am disgusted with United States service, as I have been situated, subject to the whims and orders of a macerating and ignorant charlatan; no doubt I could re-enter in winter if I wished, as all the members and Senators are friendly to my views, but I will not unless I have more scope and privileges, and can do my work in my own way. As soon as the former Commissioner, the Hon. Judge Mason, heard of my being out of the service he at once told me if I would accept a situation next fall in Iowa, he would have me appointed to make an (agricultural) entomological survey of the State; and my friend, Doctor Rock, writes to me that he is now endeavoring to have a bill passed for that purpose. This was a great compliment, as Judge Mason is universally admitted to be one of the ablest and most intelligent officers who has ever been in Government service and, as my chief, always treated me as well as possible. At the same time he told me that "he always considered me as one of the chief stays of the Agricultural Bureau, if not the chief stay itself," and paid me the compliment that the service had lost one of its best men when I left. Such things written to you

may, and no doubt will, sound egotistical, but to me they are very gratifying, as showing the feelings of my late chief.

It was at this time that he wrote :

Heaven only knows where my fate may lead me, for at present I am like a feather wafted by the wind. If a good offer were made me, would start to-morrow for either Van Dieman's land or Kamschatka.

But his fate led him to remain in Washington City for a time, where he occupied himself in making new acquaintances and gathering materials for the commencement of his work on American Entomology—meanwhile using his influence toward the removal of the chief clerk, D. J. Browne.

It has been said of Mr. Glover :

In his dealings with men he was just even to a degree that was generous ; but his prejudices were strong and almost unyielding. He never forgot a kindness, nor was he in the least delinquent in his recognition of a favor.

It may be added that he never forgot an injury and rarely forgave it ; and concerning his old chief, he always spoke in terms of most sublime contempt. He attacked his plagiaristic failings by means of the "deadly parallel" column, in the public press of the day, and wrote pages besides. His life of D. J. B. (not published), in the form of a dozen pen and ink caricatures, is as taking as a Thackeray sketch, the drawing being superlatively grotesque, while the explanations abound in telling hits. This set of drawings would bear reproduction were they not so personal. (The alligator's blood caricature is from this series.)



The Gardener's Dream.

"I had a dream which was not all a dream" (Byron)

FIG. 4. An early caricature.

While upon this theme it may be mentioned that several of Mr. Glover's caricatures, made at an earlier period, were reproduced in copper by himself for the amusement of his friends. Many others, not so reproduced, and done in ink or pencil, show him to have been a caricaturist of no mean pretensions. The drawing is frequently grotesque and the action superb, while the satire is most pointed. The caricature habit followed him through life, many examples having been made while he was entomologist of the Department of Agriculture. These were more hastily drawn, however, and were destroyed as soon as shown to a select circle of friends. But he was even more severe in shafts of doggerel verse, which were often written upon the spur of the moment, wholly impromptu, and by means of which he was able to hold up to ridicule those (sometimes in high official position) who had offended him. But he never allowed a duplicate copy to be made, and it is doubtful if there is one in existence.

For several months Mr. Glover continued to reside in Washington, and in the fall of the same year (1859) he entered the Maryland Agricultural College as professor of natural sciences, though at a merely nominal salary. Here he spent all of his time, when not engaged in field work or in teaching and lecturing, in prosecuting the work on his recently begun *Illustrations of American Entomology*, and in making a collection of birds and insects. His life at the college was uneventful, save that it gave him time to accomplish a vast amount of labor in two important directions, and in April, 1863, about nine years after his first connection with the Agricultural Bureau of the Patent Office, he was appointed United States Entomologist, under Hon. Isaac Newton, the new Department of Agriculture having been established in 1862, and he entered upon the duties of the office at once.

His first reports, issued in 1863 and 1864, being for the most part popular papers upon the more common insects injurious to vegetation in the several orders, together with brief remedies for their destruction, tell us little of his employment at this period. But we know that he made a second beginning of his museum in August, 1864, the reports of the time giving intimations of the new interest which was now absorbing his thoughts. Though the report for 1865 closes with another popular paper (relating to the uses of insects from an economic standpoint), the consideration of seeds, grains, fibers, silkworms, birds, poultry, and domestic animals, including Angora goats, explains the manner in which a large share of his time was now occupied. He received considerable assistance at this time from his confidential clerk, Mrs. L. B. Adams, a lady of fine intellectual attainments, who had had some experience in literary and editorial work, and who took a great interest in the new museum. The first part of this report for 1865 gives evidence of her assistance; in fact the preparation of these documents was the most difficult and irksome of Mr. Glover's duties as entomologist. He always shirked the responsibility as long as possible, and when it

could be put off no longer the work was begun and put through with dispatch to the exclusion of everything else. He was not a ready writer, and in much of his correspondence even, he first made a rough draught of what he wished to say, from which the clean mailing copy was afterwards prepared. Copies of official letters only were preserved, the rule of the office requiring it, as during the entire period of Mr. Glover's term as entomologist the Commissioner of Agriculture signed all public communications.

As to the manner of preparing his reports, they were usually written in pencil, with scarcely any attempt at punctuation, little attention being paid to paragraphs or even to periods and capitals; the work of putting into shape for publication, the most disagreeable of all employments for Mr. Glover, was then given to others—his earlier reports to his confidential clerk and the later ones to the writer. He always knew what he wanted to say, however, as far as subject-matter was concerned, leaving expression to take care of itself. He wrote in condensed style, at times rushing over the paper rapidly, rarely referring to authorities save where he wished to quote literally, with credit, producing his manuscript "out of his head" mainly, from a rough outline previously prepared, giving the subjects to be treated. The drawings for illustration were prepared in two ways, either drawn carefully from the insect and finished in ink, or they were cut from proofs of his copper plates, and touched up or not as might be required, before sending to the wood engraver or lithographer. The illustrations for his last report on the Hymenoptera were all reproduced from figures cut from his plates in this manner and arranged under his direction by others.

The months of August and September, 1865, were spent in Paris in attendance upon the entomological convention held that year, and at which he received the grand gold medal of the Emperor. This was given for his work on entomology, which was adjudged by the jury "to be original in its style and character and deserving to be copied by the entomologists of France as a desideratum in the application of the science to agriculture." The notes concerning the entomological exhibition as well as those relating to the industrial or economic museums visited by him during his stay abroad, appear in the volume for 1865 as a second report. Unquestionably this visit to Europe gave a great impetus to his museum work, and by familiarizing himself with the systems in vogue in other museums of a similar character, he was enabled to produce a better scheme for his own.

The year 1867 was marked by the sale of his collection of fruit models to the Government, which, with the collection of birds, included in the sale, and the mass of material gotten together during the two years that had passed since the museum was established, made quite an interesting exhibit. The scheme was now fairly realized, and, with the increased correspondence which it imposed upon the division, and the preparation of additions to its collections—now quite numerous—the entomologist's time was occupied by divided interests. The year 1867

was a busy one. The work of the division had increased so rapidly that more help was necessary, and an assistant was assigned to him. At this time Mr. Glover was very busy with the preparation of his books of manuscript notes, particularly in Coleoptera and Lepidoptera, adding to the mass of material which had accumulated for so many years compilations from other authorities, to the end of "completing to date" the histories of the insects he had figured. He was in frequent correspondence at this time with Dr. Walsh, Messrs. Uhler, Riley, Sanborn, Grote, and Robinson, and other leading entomologists, receiving from them new material for the Department collection, or to be figured in his work, sending them in return new species for description from the material which was beginning to be received from collectors in the South and West.

The museum was now attracting considerable attention, and the number of visitors was steadily increasing. To a man of Mr. Glover's enthusiastic temperament, so ready a means of imparting information and proving to the world the value of his ideas as now presented itself, was not to be lost. So it came about that by no means the least interesting of the objects there to be seen by visitors was the entomologist himself. Notwithstanding that Mr. Glover's life for many years had been that of a recluse—for in his devotion to his entomological work it amounted to the same thing—he was a social being, and thoroughly enjoyed meeting and talking with people of intelligence and appreciation, whether strangers or not. It was a portion of the duties of his assistants, at this time, to interest the museum visitors as far as possible, and to explain to them its objects and uses. Professor Glover kindly took upon himself a just proportion of this rather tedious occupation—members of Congress, Senators, and other high officials, including strangers who were in any way prominent, being his especial prey. The professor always maintained that duty alone called him from his desk upon these occasions; but sometimes there were ladies in the parties, and the frequent peals of laughter from a merry group convinced us, in our quiet corners, that the entomologist might have made himself a very agreeable society man had he chosen to divorce himself from work long enough to indulge in such frivolous existence. None could blame him if indeed this devotion to duty at such times was mere pretense, for it was almost his only contact with the world, and "all work and no play" does not conduce to the proverbial "Jack's" intellectual development.

In these years he was residing at the corner of Seventh and H streets, occupying a single room which he was pleased to call his "den," and in which, from choice, he ate, slept, wrote, sketched, engraved, and saw his few intimate friends. What with his engraving and writing tables, his book cases (constructed from boxes), trunks, tool-chest, and insect cases, in addition to the stove and regular bedroom furniture, there was little space to spare. But it was all he desired at the time, though a very great change came over him in his manner of living a few years

later, after having taken up his abode on Twelfth street, near F street. Though a single room was sufficient at first, the need of a parlor ere long began to be appreciated; and he subsequently added to his suite a bedroom for the use of his chance visitors. The larger part of his library was brought to these apartments, bric-a-brac and souvenirs of travel were displayed, his pictures hung; and as he never did anything by halves, these accumulated so rapidly by purchase that the vacant wall space of the three rooms was in time literally covered. A description of these apartments will not be out of place.

The carpeted floors were covered with skins of animals, some of them quite valuable, and not altogether devoid of beauty. In two of the windows were plants, and a mass of vines clambered to the ceiling. Near a side window was an aquarium filled with fish, turtles, and aquatic plants, an ingenious fountain, of his own make, playing upon some rock-work in the center, while English ivy was trained upon a wire trellis around the window. The books were disposed in narrow, high cases (boxes set one upon another, with glass-door fronts), and upon the dressing-case between the front windows rested a heavy silver tankard, a family heirloom. The center table was covered with valuable books, ceramics, and bric-a-brac, the mantel opposite supporting a bronze clock, with carvings and quaint metal work disposed about the shelf. Against the paneling of the black mantel were hung a collection of pipes gathered in his travels, some of them made by Indians. Around the room upon light circular stands were displayed several glass cases of richly plumaged humming birds and gaudy exotic butterflies and beetles; and over a central book-case was perched a solemn white owl in spectacles, reading its own history from a work on ornithology. This was his parlor. In the room adjoining (his bedroom) the wall upon one entire side was covered with fire-arms, bows and arrows, tomahawks, and other warlike objects, a human scalp of long black hair forming the rosette to one of his fantastic trophies. Another part of the wall was devoted to rods, nets, and implements of piscatorial sport. At one window stood his large writing table, and at the other a similar table covered with his engraving tools, etching materials, bottles, boxes, etc. Around the wood-work of the mantel-piece in this room were hung cooking apparatus, certainly showing hard usage, and at the third window, looking to the south, there were several cages of singing birds. Some easy chairs, the bed, a stove, and a small refrigerator completed the furnishing of the second room, while the third of the suite was simply a bedroom, tastefully furnished and adorned. It was a veritable curiosity shop where a very pleasant evening could be spent. I must not forget the decanter of sherry, the French kisses and confections or fruit, served upon pink shell plates, which always formed a part of his welcome to his visitors. When there were no visitors, however, the rooms were dark, save as lighted by a student lamp with a heavy green shade which always stood upon his writing table in the corner of the bedroom, for he was never idle when alone.

In 1868 the Department removed to its new building, and the entomologist was assigned to better quarters. The three or four years which followed were marked by no striking events, though Mr. Glover labored on in his chosen work more indefatigably than ever, extending his name and fame through the growth of his museum and through his writings and large correspondence, as well as by the knowledge of his progress in his work on entomology. It was during this time that a large adjoining room to his own was granted him for the use of his division, and for the establishment of an entomological cabinet. This was fitted up with low show-cases similar to those in the museum, one or two of which were supplied with drawers for the insect collections. Mr. Glover took very little interest in the entomological cabinet, however, either in the preparation of the specimens and their classification and arrangement or as a matter of reference afterward. But he always went carefully through all new collections as soon as received, in search of fresh material for his work, laying aside such as interested him, after which the remainder of the collection had no further attraction for him. He was interested in *having* a collection, though he often declared that a series of well-drawn colored figures were quite as useful.

Now comes the publishing period of his life, if it may be so termed, the years from 1872 to 1878, during which time he issued four volumes and distributed twelve sets of his entire work, all except the Lepidoptera being supplied with the names. In 1871 he took up the Orthoptera, which had been neglected by him for many years, and added half a dozen or more plates, the labors of Mr. Cyrus Thomas upon new western material (from the surveys and elsewhere) proving the incentive. His Orthoptera was published in 1872, and was followed at intervals of two years or less by the other works. This matter is fully discussed, however, in another chapter.

The incessant labor of this period, with little exercise and no recreation—not even the Sabbath rest—told heavily upon Mr. Glover. He took no leaves of absence, though repeatedly urged to do so, although occasional visits to the country or to Baltimore, upon Sundays in summer, gave him a little change from the monotony of his every-day existence. At one time he had a strong desire to visit Florida again, and later, after partially recovering from his first serious illness, he was strongly advised to go, his old friend, Mr. Wells (“Alligator”) being suggested as a companion on the trip. He continued at his work, however, though in the last year or two of his official life he was more careful of his health, eating more rationally and regularly, and partaking less of cold or such ready-cooked food as could be eaten at any time. He now devoted the Sunday afternoons, when pleasant, to walking, in company with the gentleman with whom he resided, and seemed less averse to having his evenings broken in upon by visitors. He even went out now and then evenings, when he could have the company of a friend to and from his lodgings, as it was difficult for him to get about easily after dark, and he disliked to be in the streets alone on account

of his defective vision. For this reason, during the last ten years of his life he attended no meetings of scientific or other societies, not even the meetings of the Masonic lodge of which he had been a member.

But the long years of constant application, together with possible imprudences in his manner of living and exposure to malarial climates at earlier periods, broke him down at last. We missed him from his accustomed place one morning, and when an hour had passed and he did not appear the circumstance was so unusual that a messenger was dispatched to his rooms to learn the cause of his detention. The answer was returned that Mr. Glover was very ill. How ill was not appreciated by the writer until, standing by his bedside and listening to his incoherent utterances, the unwelcome thought was forced upon the mind that his labors were nearly finished. And so it proved, for although he recovered in a measure from this sudden prostration and lived for several years, he was never able to resume his work, save as he interested himself in some such slight occupation, for sake of relieving ennui, as copying lists of names to accompany his plates. Though his successor, Charles V. Riley, was soon appointed, he was still continued on the rolls of the Department at a less salary, coming to the office as he was able, although in reality he rendered no service. But in time his health further failed him. His disease had made such inroads upon his once iron constitution that it was unsafe for him to reside in Washington away from his friends, and then he unwillingly left Washington to take up his residence in Baltimore with his adopted daughter, Mrs. D. C. Hopper.

Of the remaining years of his life there is little that can be written. Feeling that his active labors were over, he disposed of his entomological library, presented his birds, exotic insects, and other natural history specimens to the Druid Park Museum, and, as he had already memorialized Congress for the sale of his plates, his MSS. having been deposited with Professor Baird at the Smithsonian Institution, there was little to occupy his thoughts but his own sufferings and the trifling things of every day existence. Thus, almost blind and too feeble to go far from home alone, he virtually retired from the world.

After so many years of busy life in the nation's capital, the reaction produced by the life of positive repose, both mental and physical, which followed his coming to Baltimore must have been terrible. The full force of the suggestion never came to me until the occasion of my first visit to him amid his new surroundings. He evinced a boyish pleasure at seeing me, and his eye brightened as kind messages were given him from friends and associates in Washington, or when the old life was touched upon; but withal an air of sadness made itself apparent which told me that he was not altogether happy. Passing over other visits I come to the last one, some months before he died, the recollection of which is as vivid as though it were but yesterday. For a time he seemed like his old self, save that suffering and disease had laid a heavy hand upon him; but after a while he began to talk of himself,

and with a voice husky with emotion, and with eyes suffused with tears, he told me how unhappy he was and how he longed for the end to come. Among other things he felt keenly the neglect of his old friends, some of whom were residing then in Baltimore, and whom, he said, had never called upon him or helped to relieve in any way the monotony of his existence. My leave-taking from him on this occasion was most painful. I remained with him as long as I could do so, but when time came to depart he clung to my hand like a child, walking with me out upon the door-step, and stood looking after me as I walked away. I never saw him again. His death came peacefully on the 7th of September, 1883, surrounded by his immediate family, his wife, and adopted daughter, and he was laid at rest in the Loudon Park Cemetery, near Baltimore.

One who knew Mr. Glover intimately for twenty or more years of his life has said of him, "In his personal habits and intercourse he was peculiar." He was peculiar even to the verge of eccentricity, yet in summing up the many traits of his character, to his very peculiarities is due mainly the measure of success in life to which he attained. He was a man of few friends. In his youth the friendship of one or two enthusiastic boy lovers of nature, like himself, who could enter into his pursuits and think as he thought, satisfied him. In middle life, after a residence of five years in Washington, he says of himself, in touching upon this theme, "Acquaintances I have made many, but friends none." That he made few friends I think was due to several causes—a slight distrust of mankind in the first place, coupled with a feeling that too close intimacy would bring a greater or less degree of annoyance. Then he was a man so thoroughly interested and absorbed in his own pursuits that few who came in contact with him, particularly in later life, found in him that responsiveness or congeniality that one expects to call out in a thorough man of the world. But it may be said of him, once a friend always a friend.

Not averse to society, he enjoyed himself in it, yet in general terms he regarded time spent in complying with its demands as so many hours wasted. I scarcely ever knew a man whose character was made up of such opposing traits. He was most generous in many things which, in the estimation of the world, go to make up generosity, yet in the matter of personal concerns, as far as the world went, his self-interest was so absorbing that it left no heed for the interests of others. "Never trouble Mr. Glover with your own affairs" was a gentle hint conveyed to me as a piece of advice a few months after I became his assistant. Heeding it, I won, in time, his friendship, and then another side of his nature was revealed to me. An exacting task-master with himself at all times, he demanded full and unhesitating compliance with his wishes, when once made known, from those over whom he exercised authority; and yet where the disposition was shown to be diligent and faithful or loyal

he allowed the largest liberty. Strong in his opinions, preferring that his own suggestions should take precedence of the suggestions of others whom he thought less thoroughly informed upon a given subject, he was never unreasonable save when the views of others ran counter to his prejudices, and then he was as inflexible as iron. A little child could lead him, but a regiment of soldiers could not drive him.

In disposition he was serious but rarely melancholy or cynical. On the contrary, he had a rare fund of humor and a keen sense of the ridiculous, appreciating a joke whether at his own expense or the expense of a friend, and never losing an opportunity for its enjoyment. His satire was pointed, his sarcasm cutting, the most common modes of expression being caricature and verse, in either of which he was very ready. But he could also write very pleasant verse in a humorous vein when wrought up to his subject, two examples of which, in my possession, "The Velocipede" and "A Valentine" (and very personal to the writer) are highly-prized mementoes. "He never forgot a kindness," and it was not easy for him to forgive an injury, nor did he ever regain confidence in those who deceived him or endeavored to use him. Of a jealous nature, he was sometimes suspicious, and like many others with this disposition, he was quick-tempered, and his anger, when aroused, for the time being was almost uncontrollable.

Susceptible to the world's praise, he shrank from its censure, which may be given as one reason for his never having described an insect. Mr. Glover could never have been a specialist. While recognizing the importance of, and necessity for, technical work to the end of settling the vexed questions of classification and synonymy, he had no patience with those whom he designated as "species grinders," and in his private discourse was often quite denunciatory in his criticisms of their work. He often made the boast that he had never named an insect, and as often declared it to be his opinion that many of the existing species in our lists were but varieties. In his entomological work generally he was exceedingly cautious in making statements and averse to "rushing into print;" he often underrated his own judgment in an endeavor to be on the side of fact, and he was always just in giving credit to others.

In his habits of living he chose to be untrammelled by the conventionalities of custom, attending to necessities of existence in a way that offered the least personal inconvenience to himself. So the man who from having moved in the cultivated society of his home on the Hudson, had in the performance of duty come to "herd with negroes and Indians in Demerara, where a white man is as good as a darkey," or summered in the Florida swamps "with pet alligators and rattlesnakes," found it no hardship to prepare a simple breakfast while the wax was hardening upon his copper plate, or to eat it, while perchance the acid was eating into the shining metal. His walk at sundown and his restaurant dinner later, his chief mental and physical recreation, gave him zest for his evening's work.

He was methodical without being systematic. His very life in later years was a life of routine only broken here and there by Sabbath visits to "Woodside," the childhood home of his adopted daughter. Nor was he idle during these visits, for upon his return Monday morning he always brought back a considerable amount of fresh entomological material, the result of his field rambles and excursions, frequently announcing a new fact or discovery, or displaying some unknown larvæ to rear, and always exhibiting something interesting.

His enthusiasm was the mainspring of his endeavor, his untiring industry, coupled with method, the means of accomplishing the undertakings which it prompted. He cared little for the good opinion of the world as far as relating to himself personally, but he not only found pleasure in, but invited appreciation of, his utilitarian schemes. It was a great satisfaction to him to feel that he possessed the friendship and esteem of the leading scientific men of his age, but he never courted their favor, and his modesty led him to shrink from posing as a conspicuous figure among them.

Had he lived to complete his work in his own way and found means to publish it in its entirety the world would have had a better appreciation of the immensity and scope of the undertaking than any simple statements of friend or biographer will ever convey.

I will close this brief sketch with a tribute to Mr. Glover from the pen of an intimate friend, written in 1874, which appeared in *Field and Forest* four years after. The last two stanzas proved prophetic.

THE PROFESSOR.

[Inscribed to Professor G——.]

Little cares he for the world, but sits
Till evening, from earliest dawn,
And figures and etches and writes,
And the work goes bravely on.

And a monument grows, day by day,
That shall tell to the world his fame
When marble has crumbled away—
And he silently carves his name.

Carves it in Nature's soft lines,
With a graver skilled and true;
And the acid eats till the eye defines
The outline of promise in view.

And the days and years go fleeting by,
Tasks are finished and new ones set;
Still the end is not, nor draweth nigh—
There are pages unwritten yet.

Pages unwritten that ever will be,
For the longest life is a span—
That his dream may approach reality,
He is working while he can.

HISTORY OF HIS WORK ON ENTOMOLOGY.

Mr. Glover commenced his immense work on insects, known as "Illustrations of North American Entomology," in 1859. Portions of the work, that is, special plates of the orange and cotton insects, were engraved a year or two prior to that date; in fact, it may be said that he made two or three beginnings prior to the commencement of his ultimate scheme. A very early idea was a set of pocket plates representing the common injurious species. Quite a number of these were engraved by him, the plates, or a part of them at least, having been deposited in the National Museum with those of his later work. These little plates measure about $2\frac{1}{2}$ inches by 4, the figures chiefly relating to the commonest forms of beetles and the smaller moths, with a few of their larvæ, and a few insects in other orders. The plant affected usually appears in the center of the plate, greatly reduced of course, the insects in some cases being placed upon it. The work is well done, some of the figures being very soft. From a study of his early plates I place them among the first that he did after coming to Washington and while in the employ of the Patent Office, probably 1855. It is interesting to note that on all of Mr. Glover's early plates, made in any consecutive number, whether upon stone or copper, the idea of showing plant and insects together appears, and the same idea was carried into the first plates of his final work, though soon abandoned.*

His second beginning was the outgrowth of the scheme for a grand work upon economic entomology on octavo plates which should comprise the principal plants of American agriculture, with the insects figured upon them. A motive for such work appears in the set of exquisite water-color drawings of flowers and insects, painted by Mr. Glover when a young man, and to which allusion has previously been made. Here are shown the plant, flower, and leaf, and the various stages of some species of the insect known to feed upon it. In a letter written to Mr. Clapham in 1856, where he alludes to a scheme for an agricultural museum, he says:

Another idea is to go on with my work on insects—to have large engravings of our staple agricultural productions, such as cotton, corn, wheat, potatoes, and so forth. On the wheat root place the cut-worm, chrysalis, and moth; on the ear place the wheat midge, etc., in short, to place every insect that destroys wheat upon the part injured, natural size and magnified, the plates to be issued by the Government, and distributed to every leading society, to be placed in their agricultural rooms. By

* I have nearly the full series of his early plates, given me by their author from time to time, the collection forming an interesting study.

looking at the place affected the farmer can see the insect in all its stages, and, at the same time, by referring to the Patent Office Agricultural Reports, can find out the remedies in general use.

That Mr. Glover contemplated such a work before he came to Washington is evident from a number of plates on stone still in existence, made early in the decade from 1850 to 1860. He has more than once alluded to it in conversations with me, and but for the counter interest in pomology, and in the preparation of his models of fruit, he would have attempted it at that time. I take pleasure in reproducing here a plate made by him in February, 1852, which contains some ten species of insects, all of which are tolerably well drawn. (Fig. 5.) His work at

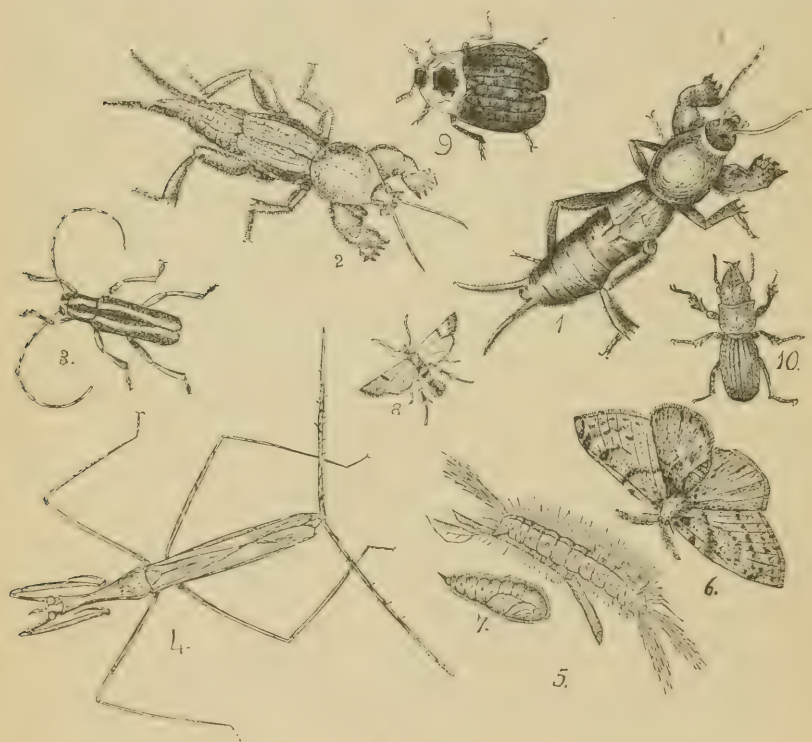


FIG. 5.

that period had attracted the attention of Dr. Harris, and some ten months after this plate was made he was in receipt of a letter from the doctor acknowledging his superior skill in the delineation of insect forms, and asking his co-operation in the preparation of a new work on entomology. I give herewith the main portion of Dr. Harris's letter, only omitting a page or more of explanation of figures in the plates Mr. Glover had sent him. It is as follows:

CAMBRIDGE, MASS., December 15, 1852.

DEAR SIR: Your letter of the 7th instant with the specimens of your engraving and the drawing of the pear-tree insects, reached me this day, and I am very much gratified by these tokens of your remembrance.

Some time last summer another specimen of your skill was sent to me from the horticultural hall, in Boston, but at that time I was very much engaged in preparing copy for the printer, and carrying through the press a new edition of my "Treatise on Insects Injurious to Vegetation." My tables were covered with manuscript proof-sheets, specimens, and various miscellaneous matters, among which your engraving was lain, and it has disappeared in one of the clearings up of my clutter. It is not lost, only mislaid, and will come to light again without doubt when I can muster resolution and find time to overhaul my papers. I name these facts to account for my apparent neglect to acknowledge your favor. My book at last is finished and bound; and now, if you will tell me how I can send a copy to you, it will give me much pleasure to forward it to your address. My scientific friends tell me that all the book wants is a set of figures to illustrate the descriptions. I am fully sensible that its value would be much increased by such illustration, and that it would then supply fully a want that has long been felt for a work combining scientific descriptions of our most common destructive insects with good colored figures of the same.

I am very much pleased with your success in engraving on stone. With practice you will doubtless acquire the skill to represent insects in the very best style of this kind of engraving. This kind of work is much to be preferred to engraving on copper, because of its general cheapness; the stone admitting of being ground down and used again; and a delicate and skillful engraver can represent insects about as well on stone as on copper. I think you will find it quite as easy to execute engravings on stone as on copper, and I hope you may be induced to perfect yourself in this art. Your specimens certainly do you great credit, and I am very glad that you have so promptly and successfully acted upon my suggestion. * * *

When you write me to inform me how to send you my book please to let me know what you consider would be a fair price for the engraving of a plate with insects on it of the size of your specimen plates. The cost of striking off, which must be done by the press, would be another matter, and may be known by inquiry. It would depend in some measure, also, on the number of impressions wanted. I very much wish some arrangement could be made with you for preparing a series of plates to illustrate my book. To do this, however, it would be necessary for you to take up your residence here. The plates might be issued in numbers, accompanied by brief descriptions referring to pages of the treatise. I have also another plan in view, which has long been a favorite one with me, namely: To prepare a series of small popular volumes on our insects, with plates, somewhat like Jardine's Naturalist's Library, to be entitled *Insect Biography*. The first volume to contain a brief, general introduction somewhat like the introductory chapter of my treatise, with figures illustrating the orders of insects. The second to treat of principal families, illustrating them with the biography of one or two common insects of each family. The third to take up some large group and describe and figure the most prominent species in it, and so on with the other volumes as the public taste and demand for the work might guide or encourage it. A work of this kind would do more to promote a general taste for entomology than anything else, and I think it would meet with very good encouragement. Hitherto I have been deterred from undertaking it for the want of co-operation of a competent artist to execute the plates; our engravers having no skill in such matters and no taste to make themselves acquainted with the details of insect structure, and, moreover, being extravagantly high in their charges. Sonrel, a Swiss engraver, is the only person who can do such work at all well, and he being a foreigner and not speaking English well, it will be difficult to get along with him. Please let me know your thoughts on these plans of mine.

Truly yours,

THADDEUS WILLIAM HARRIS.

MR. T. GLOVER.

Mr. Glover did not take up with this offer, as he doubtless had other plans in view for himself; but the letter is interesting, as furnishing evidence that Mr. Glover not only worked upon copper at that early date, but also upon stone. I have in my possession proofs of a number of these plates engraved upon stone, the execution of which is far better than the work on his copper plates of the same period. Of one of these, illustrating parsnip insects, Dr. Harris says:

No. 1 is apparently one of the *Ortalidæ*; its larva unknown to me before. No. 2, I have often seen the larva of this moth, but never succeeded in obtaining the perfect moth.

So Mr. Glover was a good observer, as well as a tolerably skillful engraver at this time.

Mr. Glover's reply to Dr. Harris's letter would be interesting could it be produced. I have searched for it among the Harris correspondence at the Natural History Society rooms in Boston, but without avail. The letter was very flattering to Glover, as he has himself told me; but he was not then ready to enter into such an arrangement. What other correspondence may have passed between them at that time can not be stated, but a little over two years after Mr. Harris wrote another letter, which not only gives some interesting facts in Harris's life hitherto unpublished, but is certainly most complimentary to Glover. This is the letter:

CAMBRIDGE, MASS., *February 13, 1855.*

DEAR SIR: On the 4th of September I received a letter from D. J. Browne, esq., then at New York, and on the point of sailing for Europe, informing me that you had been engaged in making drawings of insects to illustrate the next agricultural report of the Commissioner of Patents, and wished to pre-engage my co-operation with you. He further informed me that you were then absent from Washington, somewhere in Georgia or South Carolina, and that on your return in November you would visit me in Cambridge. He also stated that he would communicate with me again on the subject on his return from Europe. Under these circumstances there seemed nothing for me to do but to wait till I saw you or till I heard from him. Moreover, my oldest son was dangerously sick and remained so till his decease on the 19th of October, and in our trouble Mr. Browne's communication was entirely forgotten till it was brought to my mind by a letter received from Hon. C. Mason on the 29th of November. To this letter I replied on the 8th of December, since which time nothing has been heard of the subject therein proposed. I hope that you have seen my answer to Mr. Mason; if you have not, let me beg you to request him to show it to you. I shall be happy to render you any service that is in my power consistent with my other duties and engagements. These will fully occupy me from the 1st of March till the middle of July; so that you must not count on me for any assistance from me during that time. At this present time, having a vacation in college, I am more at leisure than usual. I regret not to have received the expected visit before the opening of the college session.

Indeed, I have been long expecting a visit from you as promised some two years ago, in which I hoped to have made some arrangements with you for illustrating my work on insects. The time is come in which I have an expectation of being able to defray the expense of illustrations to the work, and in which it will become necessary for me to take some decided measure for having them done, if they are to be done at all. The committee on agriculture of the legislature of Massachusetts are now considering the expediency of printing another (the third) edition of my work

with illustrations. Moreover, overtures have been lately made to me by a publishing firm in New York to get out a duodecimo edition of the book, in which it would be easy to introduce wood-cuts, if a competent artist to make the drawings could be obtained. My first proposal having been made to you to furnish illustrations, and having ever kept this in mind, I now return to the subject to inquire whether your engagements will allow you to undertake the same, and on what terms, and what time you will be ready to begin. It would best promote the object were you situated in the immediate vicinity, for I should need to communicate almost daily with you while engaged on the work.

You may remember my having stated my wishes regarding another work, or rather a series of works, of a popular character, on our insects, in which I hope to have your co-operation. The plan has long been matured; the execution with the means now on hand would not be difficult, and the success seems to me to be almost certain. With the pictures the books can hardly fail finding a good market. Without boasting, I may be permitted to say that we could do in this department, together, what no other persons in the United States can accomplish.

Have you seen Dr. Emmons's big book on the Insects of New York, or Professor Jaeger's smaller one on the Life of North American Insects? These will be a warning against any one's undertaking to deal with subjects with which they are not familiar. Criticism will be thrown away upon them, and I forbear making further remarks upon these remarkable productions.

Do me the favor to write to me at your earliest convenience and let me know what is the extent of your previous engagements and what your plans are for the future.

Yours, truly,

THADDEUS WILLIAM HARRIS.

TOWNEND GLOVER, Esq.

I may mention here that, as far back as 1847, Mr. Glover spent some time in Albany with Gavitt perfecting himself in work upon copper, particularly in the handling of the roulette, by means of which the dark effects in illustration are produced, as shading of wings, bodies, etc. Among his early copper-plates is the one executed in February, 1852, reproduced above (Fig. 4). Some of the figures on this plate show clearly the methods used with stone engraving, namely, stipple shading, as seen in figures 3, 4, and 10, especially. In 1 and 9, on the contrary, the same effect is arrived at by means of lines, though apparently by a hand not thoroughly skilled.

To return to Mr. Glover's plan of a work on insects, as outlined on a previous page, it is impossible to say how far he progressed with his scheme before finding it impracticable. The plates of the orange insects finished in accordance with it (though only approximately) are to be found, pretty nearly as originally engraved, in the Homoptera of the final work by which he is now known. The 22 plates of Insects and Diseases of the Cotton Plant are included in the 273 plates sold to the Government, but were finished, or very nearly so, while he was yet in the service of the Patent Office. Some extracts from his journal in 1858, when in Florida, throw very interesting light upon this point:

June 28: Began plate on Coccus. *July 6*: Began Plate 2, lemon (coccus). *July 9*: Commenced plate of Papilio thoas, on orange. *July 21*: Began coccus, Plate 4; orange; etching all day. *July 24*: Finished Plate 4; afternoon to Redwater Branch, and brought home cargo of red-bugs. *July 30*: Finished Plate 5. (The next day he

commenced Plate 6, cotton terminal shoots.) *August 6*: Commenced Plate 7, young boll. *August 9*: Commenced Plate 8, Orange Aphis, grasshopper, etc. (insects of different orders on the same plate). *August 16*: Commenced Plate 9, orange-scale parasites. *August 20*: Commenced Plate 10, Saturnia Io. *August 26*: Began Plate 11, *Trichius delta*, and cotton flower. (The last mention of his plates is in the entry for September 25.) Finished Plate 16, corn worm, and have no more plates to do. Have written to Washington for them, but, like all I write for, nothing comes.

After that his only work on plates was retouching and burnishing. That these plates were not all that he made for the cotton and orange series is evident from various allusions to "etching" in the journal for the year 1857, while in Mississippi, one entry being "etching cotton blight."

The above extracts show the design originally of a work on cotton and orange insects, in which the insects of different orders, on the same plate, were grouped together indiscriminately. Other plates were prepared in accordance with this purely economic scheme of arrangement, and some of these, on which some one order of insects predominated, were afterwards incorporated in the final work, the inappropriate figures being burnished out and other insects substituted. Some of these plates may be known in the "illustrations" by having a flower or part of a plant in the center, around which the figures are arranged. Other plates, made in accordance with the purely economic scheme, were suppressed altogether.*

I notice in the private journal for 1855, at which time Mr. Glover was in Florida and the Carolinas, under date of June 19, this entry: "Drawing and sketching—improved method of coloring—pressed insects." A note-book of this year's work was filled with lepidoptera drawn (?) after this method, the process for which, when Mr. Glover first showed me the series, he described as follows: The wings were carefully detached and laid in proper position, after which very thin paper, coated with some adhesive substance, probably mucilage, was pressed upon them; after going over every portion carefully, with gentle pressure, to insure complete contact, the wings were removed, the *scales* only remaining, by which means a very perfect fac simile of the markings was obtained. The fragment of paper was then carefully trimmed to exact form of wing, glued upon the pages of the note-book, body, etc., *sketched in*, and the figure was complete. I think Mr. Glover only employed the process (in part) during one or two seasons, as he explained to me that its chief use was to save time in making drawings, or the annoyance of carrying around a collection of the preserved insects.

After leaving the United States Patent Office, in the winter or early spring of 1859, Mr. Glover gave himself heart and soul to his final conception of an illustrated work on entomology, for he had realized the

* The writer has a number of proofs of these, as well as impressions of two or three plates as they appeared before alteration and the addition of new figures. (See plate XXVII, Coleop.; Plates III, IV, and V, Orthop.; Plate XXIV, Lepidop.; and Plates IV, V, and VI, Homoptera, as illustrations of *adapted* Plates.)

difficulties in the way of carrying out the former scheme and abandoned it. In July, 1859, he writes to a friend as follows :

Since I left the office I have had several offers from various States to continue my work; and probably in the autumn I may make some arrangement with them, but at present am collecting material for a large work on entomology, more especially connected with agriculture. I have already in four months etched and nearly finished twelve copper plates, large octavo, comprising nearly 150 of our principal Coleoptera, beginning with the Cicindelidæ and Carabidæ, as beneficial to the agriculturist, inasmuch as both larva and imago destroy other insects injurious to the crops. I intend at the same time, to make my work useful to the entomological student, as I shall figure specimens of all the leading families unconnected with agriculture; and as there is no such work in America, I am encouraged by the scientific men here. The work will not be finished for at least three years, but by that time I hope to have at least 1,500 to 1,800 specimens etched and colored.*

Of the habits of his life at this time, not dissimilar to the habits of his later years, the same letter gives a number of hints. He calls it a hermit's life: up at 6 or 7, breakfast in his "den" (the writer of this can readily picture both "breakfast" and "den"), after which he smoked "a hookah" (nearly ten years later he gave up smoking altogether); the rest of the day, until 5 o'clock, being given up to the arrangement of his specimens and to etching.

Then he took a restaurant dinner, "Jewish passover fashion, with cap or hat on," after which he hunted for specimens, and returned home about 8 o'clock in the evening. From that time until 10 o'clock he made his notes of the day, searched for references, and then to bed. An exacting task-master, he applied himself without cessation, inaugurating that severe routine in his labors, with little or no recreation, which marked the last ten years of his life. At this time he wrote: "My maxim now is '*nulla dies sine linea*,' and it is astonishing at the end of three months to see what the motto will accomplish." But the results are due not to the motto, but to the persistent application, which in Mr. Glover was second nature—more marked in his case than in that of many men who perhaps have produced greater results, for he literally did not allow himself any recreation besides that which was demanded for the hours of sleeping and refreshment.

To his cousin, Abram Clapham, of Leeds, England, he writes at this time as follows :

If you can procure me specimens of your common British insects, without trouble, I would be much obliged, as I want them for comparison, to find corresponding types here, and to see what differences there are between our Agrotidæ and the cut-worms of England, as I believe that many will be found to be perfectly identical. Several insects have been imported we all know. Take, for example, the *Galeruca californiensis*, which is even at the present moment destroying all our European

* His work was commenced about March 1, 1859. From that time to the date of his entering the Department of Agriculture, in 1863, was about four years. He held the position of United States entomologist just fifteen years to a day, making nineteen years of labor upon his undertaking up to the time it was so suddenly discontinued by the breaking down of his health. How many more years he would have worked upon it, had health been spared, it is difficult to say.

elms in Washington. And please, if you send any, at the same time send the scientific names, as I can then identify them by referring to English works. By the way, what are your best agricultural entomological works, as I shall order them here? I have Morton's *Encyclopedia of Agriculture*, Westwood, and sundry other English works; have ordered Ratzburg's *Forst Insecten*, etc., so that I shall also be able to compare with the German. Dr. Girard, who is at present in Germany, has promised to send me all the German insects he can procure. If you know of any one who has about £5 worth of *common* (*no rare*) insects to sell, please let me know. I want those principally that injure crops, and of all orders. As soon as my plates are finished I shall send you a copy, as likewise of the cotton and orange insects I finished whilst in the service of the Patent Office.

Mr. Glover was now in his forty-seventh year. Of his work during the last six months of 1859 there is little to record, save that he applied himself most industriously to his undertaking. After becoming connected with the Maryland Agricultural College, about 1860,* he found himself in better position to push his work. Living in the country, there were more opportunities for observation and for the study of the habits of insects. Then he was accompanied in his field rambles by his students; and with their aid, and the material contributed from his breeding cages, he soon accumulated a fair collection of the principal insect forms of the locality. Always ready with his pencil and colors, he figured everything he saw that was thought to be new, even making drawings of caterpillars and chrysalids of species that he was unable to rear to the perfect state, and which in many instances he was not able to identify until years after. Some have never been identified. This partially accounts for the incongruous arrangement of the insects on the later plates, as relating to classification, in comparison with the earlier ones, where family grouping of well-known forms is the rule.

It is to be regretted that Mr. Glover did not regard his insect collection of more value, and had not shown more care in the preparation and after-preservation of the specimens. After figuring an insect the specimen had little further interest for him. Indeed he did not take the trouble to set some of them at all, or only in such manner as would admit of their being correctly drawn. He used for the purpose entomological pins, the ordinary pins of the dressing-case, or even needles; the specimens were set at various heights, and were sometimes badly damaged in the mounting. Many of the *Lepidoptera*, as well as other forms with large wings, were most carelessly prepared, these appendages drooping or sticking out in several directions. When I first saw his cases, in 1866, the ravages of mold, verdigris, and anthrenus appeared in almost every box; single wings, antennæ, and legs were often wanting, and now and then a body. Nor could it have been otherwise, for the boxes, made to open like books, were mostly without cork, the tough pine wood at the bottom making it difficult to secure a specimen, the pins being frequently bent or broken at the points and sometimes turned at a right angle. Had his collection been better preserved and his types

*I can not learn the exact date of Mr. Glover's connection with the Maryland Agricultural College. It must have been the latter part of 1859.

for illustration indicated, the necessity for subsequent identification of many of his figures from the figures themselves would have been obviated. Some figures, particularly moths, have never been identified and are not named upon the plates. It is, of course, recalled that he figured many loaned specimens, particularly upon his later plates; these also should have been indicated in every case, although any doubtful identification, as they were received from specialists, is hardly a probability.

I am at a loss to account for his lack of system and want of care in so important a matter, when he showed such nicety, and such delicacy of manipulation in the preparation of his bird collections, unless it came from his belief, frequently expressed, that figures were as good as originals, and far more easily cared for.

When it was proposed to establish an insect cabinet in connection with the museum of the Department of Agriculture, examples of the latest and most improved cases in use at Cambridge for this purpose were obtained and brought to Mr. Glover's notice. It was a peculiarity of his nature that he took slowly to "new-fangled notions;" and partly considering the expense, he decided that shallow pine drawers with loose glass covers were good enough. He was prejudiced against cork bottoms, though the use of cork was strongly urged, and finally compromised on paper felt. As the sequel proved, the splitting and shrinking of the cases and drawers in the dry steam heat of the Department building altered his views materially, but only when it was too late to remedy the matter.

In the letter previously quoted Mr. Glover states that his work will be finished in three years. The time had expired a year previous to his again entering the service of the Government, but I do not think even at that time that the work was any nearer completion, as regards his own ideas upon the subject than when he had been working four months. It is evident from the very manner in which he worked that he had placed no definite limit to it. He conceived the scheme, and seemingly without having measured the magnitude of the undertaking, he went industriously to work to carry it out. As the end proved, "completion" in this case meant when there were no more insects to figure, for with no fixed limit it could have been carried on indefinitely.

Mr. Glover became Entomologist of the Department of Agriculture April 1, 1863. It was then located in the basement of the Patent Office building. In time two rooms were secured for the purpose of a museum, and in the corner of one of these the Entomologist finally established his office. This was in the summer of 1864. A letter to Baron Osten-Sacken, written in October, 1864, in reply to one from this specialist, shows that his work was now temporarily interrupted. He says:

* * * I have been so much engaged for the last year in the Department of Agriculture, with office work and laying the foundation for an agricultural museum, that

I have not been able to etch at all, so that my work remains at a stand-still at present. In a few weeks, when I am not so fully occupied as I am now, I intend to recommence etching, when I shall be happy to attempt your plates,* although I am afraid that you overestimate my abilities to do them, etc.

For the next two or three years his work was still more or less interrupted by Department affairs. There was now a divided interest. The new museum had been established, and to a certain extent it absorbed his attention and his thoughts. Then in 1865 he spent several months in Europe, as has been mentioned, the exhibition of insects in Paris calling him abroad. I have his Paris note book, filled with pencil outlines of insects, and with written descriptions, which tells how well he spent his time while there. And the fact that the design of his work secured to him the grand gold medal of the Emperor above all other competitors was proof that it was practical and valuable even at that time, when it had not reached the half of its present scope or dimensions.

The writer became Mr. Glover's assistant in the Department of Agriculture in 1867. By this time entomological science in America had made such rapid strides and the study had become so widespread that there were workers and observers in all parts of the country. Through acquaintance and correspondence with many of these and through the regular correspondence of the office he was now able to secure large acquisitions of new material, so that the work, for a time partly neglected, was now being pushed forward uninterruptedly, saving the interruption of official hours, from 9 a. m. to 3 p. m. As near as I can recall, on hasty examination of the plates, the Lepidoptera had been completed, at this time, to plate 67 and supplement D, the supplement series having been commenced in order to keep the diurnals and their larvæ together upon consecutive plates as the work progressed, the numbered plates being devoted to the moths. The Coleoptera had only reached plate 28; the Orthoptera less than half its present number, 18; and the remaining orders even a less number.

Meanwhile the text to accompany the plates was begun on somewhat the same principle as the ready-reference books which Mr. Glover had from time to time prepared for his private use. The earliest of these reference books were compiled or prepared in the years of service in the Patent Office (or perhaps even earlier), and at first, seemed to have been used by him as "vest pocket editions" of notes on the habits of common insects. They were tiny blank books, measuring $2\frac{1}{2}$ by 4 inches (of the size of a small pocket diary, and no thicker), into which had been closely copied, in penmanship as clear as copper-plate and as fine as print (250 to 300 words to the page), the chief facts connected with the natural history of well-known and injurious species, the food plants, habitat and other brief data, the whole conveniently arranged and in-

*These were *drawings* of the wing-veins of some thirty or forty species of Diptera, and which he afterwards prepared.

dexed for use. A photo-engraving of one of these pages, exact size, is here reproduced (Fig. 6):

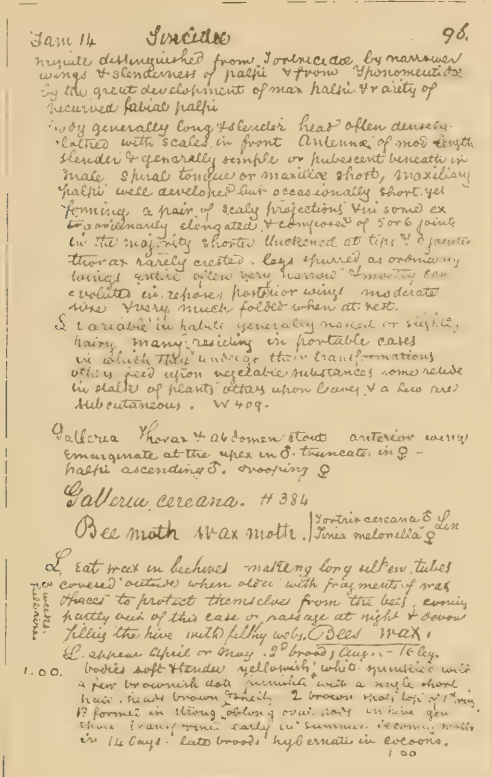


FIG. 6.

By the time the numbers of his plates had assumed some importance a set of larger note books had been prepared, into which he recopied the data above mentioned, together with notes of his own observations, besides references to figure and plate of his own work. These were prepared for each of the principal orders; and for two or three, as the Lepidoptera, Coleoptera, and Diptera, an additional series in which the food plants were alphabetically arranged, with a list of the species of insects frequenting or destroying them following each plant named. In time, as the number of plates increased, as his observations became more extended, and entomological publications had become more numerous; and as the old books were bursting their covers, a set of letter-size blank books were obtained, and the entire mass of notes recopied on a far more exhaustive plan, the whole finally constituting the material of the text which would accompany the plates when published.

This was evolution pure and simple, for I have always considered that the text of Professor Glover's work was the direct outgrowth of

these little pocket reference books, a number of which he gave me, and which are valued souvenirs.

When recently examining the manuscript left by Mr. Glover, now in the National Museum, I found with his text of the Diptera the preceding volume of notes also, from which it had been copied, illustrating perfectly his method, as described above. In this volume, as with others, when the blank pages had been covered, slips of paper of various shapes and sizes were pasted in; the accumulation of these slips and the inserted pages making it in time difficult to find any thing readily, and then the new blank book was necessitated. With each recopying he made changes, revising; adding new facts, and giving fuller accounts of particular insects, so that the new volume of notes in a short time grew to twice the size of the one that preceded it. As another example, the manuscript of his "list of animal and vegetable substances injured," accompanying the Lepidoptera, in all something less than 100 pages, he copied in seventeen days, in the winter of 1870, the dates of commencement and completion being recorded on one of the fly leaves of the volume.

The fact that the text of his work was brought together in this manner will account in a measure for its apparent incongruity in the different parts, considered in the light of an entomological work, which the plates were supposed to illustrate. In reality the plates were the "work," and the text or subject-matter a secondary consideration. That it has been gradually evolved from a very early beginning is shown, too, by its many references to Westwood, to the old German work by Leunis, and other of the earlier authorities whose publications in modern times have been entirely superseded by the many recent works that have kept pace with the progress of entomological science in the United States. As these extracts and references referred chiefly to general habits of groups and families and to classification, the necessity for a later revision was not fully appreciated. Mr. Glover always had a very high appreciation of Westwood,* regarding the work something in the light of an entomological bible, and to that extent always a safe rule and guide for the seeker after truth. In minor portions, therefore, his text was not fully adapted to the American student; and his material from Leunis less so. In his treatment of species, however, he aimed to give in very condensed form the *known facts*, from whatever reliable source they were obtainable. That the work remains in an unfinished condition is due to the sudden failing of his health.

But the *scheme* of the work as contemplated by its originator was a grand one. No more complete *reference book* of entomology was ever conceived or more practically carried out as far as he had been able to carry out the design. This, in substance, is the scheme of arrangement as far as relating to species.

*Introduction to the Modern Classification of Insects, 2 vols., 1839.

Under the name of the insect appeared first the Greek or Latin derivation (both genera and species); then followed the reference to plates and figures of the work, for sometimes the larvæ and imago were figured upon different plates, and even the male and female appeared in different places; then a list of the synonyms, followed by a short and concise account of the life history of the species, from egg to imago; then followed *habitat*, food plants, and, lastly, the best-known remedies, the parasites, and references to other authorities. In another portion of the work was given alphabetical lists of the food plants in the different orders, with the insects figured upon them; and the whole work was to be so simplified and made so available for consultation by an admirable system of cross-references that the merest tyro could make use of it. When a new fact was discovered it was at once jotted down in the proper book of manuscript notes. When a new number of some entomological publication was received it was carefully digested, and the new facts transcribed into the appropriate place, with due credit, so that the work grew by almost daily accretion to its pages, and, as far as the later material is concerned, it was up to date. In these manuscript notes Mr. Glover should have indicated, however, the records of his own personal observations. How much injustice he may have done himself by locking up in an unpublished work the results of these observations for many years will never be known. The folly of prematurely "rushing into print" is conceded; but it should be known that Mr. Glover made many new and interesting discoveries that were worthy to have been placed on record at the time of their discovery that he received no credit for whatever.

Some of these he was urged in vain to publish by contributions to the scientific periodicals of the day; but always looking forward to that indefinite point of time when his entire work would be completed (as though it ever could be finished by such a man while there were insects to figure or new facts to record), he declined publishing any portion fugitively, save as it might be appropriately used in his special reports as entomologist of the Department of Agriculture, and even then he used as little as possible. He was extremely cautious in making statements, disliked criticism, and oftentimes in giving the life-history of a particular species, stated the facts on the authority of others, with credit, in preference to his own, when both were equally full and authentic.

If he did not give to the world the results of his observations during these years, the entomological world was kept fully posted as to the progress he was making with his plates. Dr. Walsh, Messrs. Grote, Saunders, Strecker, Sanborn, and others loaned him box after box of unfigured species, which, with other material, enabled him to complete almost two plates a month. Copies of these plates were printed as soon as the engraving was finished and corrected, and after coloring half a dozen or more copies of the plate with his own hand, they were mailed

to leading authorities whom he wished to compliment, or to those who had loaned him insects. The borrowed material was not necessarily retained until the plates had been finished, for his first work on receipt of a species new to him was to make a careful drawing of it in detail, after which it was colored to life; the name was then written upon the drawing, together with brief notes (sometimes) for his guidance when it came to be engraved. The plates were laid out most carefully and the position of each insect indicated before a line was drawn. The figures were then carefully traced upon gelatine, the lines filled with dry red lead, and the outline transferred to the copper. After this they were etched and finished with the graver in the usual manner.

It has been a matter of surprise to me that Mr. Glover did not more carefully preserve the original drawings from which the figures on his plates were engraved. Many he did preserve, but by far the larger portion of the earlier ones are not now in existence, as far as I have been able to learn. Some of the more recent ones are now in the possession of the National Museum, though chiefly relating to two orders.* But he always made a practice of coloring the first copy of a new plate very carefully for his private set of plates, his working set, as he called it,† and subsequent copies were colored from this.

In 1868, when the Department of Agriculture was removed to its new building, the entomologist was able to have a room to himself, to which he brought a large library, and where he deposited his plates for safe keeping. An amusing peculiarity of the man at this time was shown in the matter of book-shelves, which, for reasons of his own, he fitted up at his own expense, from boxes, though there was no necessity for his doing so.

He was now allowed a special museum assistant, a taxidermist, and a messenger, in addition to the regular entomological assistant, and the demands of the museum upon his time were thereby lessened. This left the hours of official duty more free for entomological investigation, for the compilation of notes from current literature and from authorities which previously had been only partially reviewed; though it should be stated that no inconsiderable portion of the day was devoted to callers, and to those seeking information upon a wide range of subjects connected with the museum display or otherwise. To all he showed the utmost courtesy, though the more prominent of his visitors were invariably taken to his private office to see the work on insects. The scheme was there unfolded in detail, and he ever delighted to talk to an intelligent listener. He described the design in full, and at the same time illustrated its utility by referring to some well-known injurious species, invariably closing with the reading of a brief account of its history, with references to remedies and to the figures of the insect in different stages upon his plates, and with the stereotyped query: "How do you like the plan?"

* Many of the Florida drawings are in the Harvard College library.

† This is now in the National Museum.

There was a humorous side to this almost daily practice, which is also illustrative of the man. Occasionally it happened that he told the story a second time to the same individual, who was dropped politely, but instantaneously, when he had learned of his mistake; and an incident like the following was not of infrequent occurrence:

Enter visitor, who grasps his hand warmly and familiarly, showing the greatest interest in his entomological work, and perhaps introducing a friend who is with him. The professor makes a great show of delight at again meeting him, quietly gets him into the museum, and excusing himself a moment, rushes into the room of his assistant with a half-whispered: "Charlie, who the d—l is that?"

As every man is said to have some particular weakness or idiosyncrasy, Mr. Glover's seemed to be an absorbing pride in his work on entomology and in his museum, which amounted to almost childish vanity. A man who cared little for compliment in a general sense, his work was his life, and he expected every one with whom he came in contact to appreciate it almost to the point of his own enthusiasm, which was boundless. On the other hand, disparagement hurt him like the barb of an arrow. Sensitive as a woman, he could not bear adverse criticism, published or written. It seemed to him almost a personal thrust, and where one showed the least approach to being hypercritical, it filled him with most unkind feelings toward the author. Nevertheless, friendly criticism given in the shape of kind advice or suggestion, if delicately put, was always thankfully received, and particularly from those whose opinion or judgment he respected. I can not but recall a certain correspondence with Dr. Walsh, relating to some accidentally damaged insects, which, if produced here, would prove spicy reading. There were others, too, with whom Mr. Glover seemed always at swords-points whenever he came in contact with them, and towards whom he was wont to express himself in the most emphatic language, for he was a royal hater.

As an illustration of how Mr. Glover's feelings could be outraged by unjust censure and fault-finding criticism, reference may be made to a little publication issued in 1872, purporting to be a history of the Department of Agriculture, from the pen of its chief clerk, which aroused his indignation and stirred him to the very depths. The work of the division was commented upon in an exceedingly unkind way, a garbled quotation from one of the professor's reports given, making him say in substance that the new facts and the records of observations emanating from the division were quoted "extensively" from the published material of other entomologists, who were named. The remarks which followed were filled with left-handed compliments, written in a satirical vein, and closing with this extract:

It is not required of the entomologist that he should visit the fields and orchards, and there study the habits of obnoxious insects of which but little is known. A contrary impression has been entertained; but it is proper that the exact truth should be stated. It would seem, however, that the entomologist of the Department should fre-

quently verify, by personal observation in the field and orchard, the correctness of the theories and suggestions of other entomologists, and there aid them in devising remedies against ravages of insects. Many State governments have employed entomologists to aid the farmers in their warfare against noxious insects, and in this great work, which requires that the broad country be frequently visited, the entomological division of the Department of Agriculture might sometimes, without presumption, take the lead.

Mr. Glover defended himself in a little brochure which he called "*A Vindication*," which was published shortly after, wherein the extract referred to was given in full, the extent of quotation from other authors stated, and other portions fully replied to. Moreover, the chief clerk was privately held up to ridicule in a clever bit of doggerel verse, which the professor read to all his intimates in the Department, though it was not permitted to get out of his hands.

Regarding the fact that the Entomological Division was not engaged in field work throughout the country, Mr. Glover considered that his twelve years of previous field work amounted to something, and also maintained that it was sufficiently difficult to obtain the necessary funds for the routine work of the division without considering the greater expense of field observations and investigations. On this one point I think Mr. Glover was open to criticism, as he never made the effort to secure appropriations for the purposes of field work, but rested on past laurels. His private work may have been partly responsible.

I think the period from 1869 to 1872 marks the most active years of his entomological work during his connection with the Department of Agriculture. Not only was he more interested in the work of the Entomological Division, but the preparation of the text of his private work received a greater impetus at this time, while the engraving of his plates was steadily pushed forward. By 1870 over ten years of labor had been spent upon his undertaking, and it had grown to such proportions that the framed plates, cut to octavo size and hung upon racks nearly 7 feet high, occupied one entire end of the Museum hall, which was 50 feet wide. His life was now a perpetual round of systematic employment, and he was even more settled in his habits than in 1859, when he detailed to a friend how he spent his time in a letter previously quoted. Frequently up as early as 5 in the morning, he etched or drew until almost 9, saving a short intermission for breakfast, which for many years he had been in the habit of providing himself; though later, to save additional time, it was prepared for him and sent to his room. The hours from 9 to 3 in the afternoon were spent at the office in an entire change of occupation; then back to engraving again, which occupied him as long as he could see; then he took a short walk and obtained his supper. The evenings were always spent in writing; and it was a matter of pride to accomplish each night a certain task which he set for himself, and which he would not relinquish until the last line was written.

As Mr. Glover finally sold his plates to the Government (he gave his manuscripts for nothing), the question has more than once been asked of me if he ever employed himself upon them in any way during the hours of official duty. To this question there is but one answer. No! Mr. Glover himself appreciated the force of the suggestion and the possibility of such a charge being made; and, not to be misunderstood in the matter, he rarely lost an opportunity to explain to visitors, while showing his work, that it had all been done "outside of office hours, before 9 o'clock and after 3." Naturally the phrase in time became stereotyped.

The closing of this period marks the opening of his publishing period, as may be termed the years from 1872 to 1878. For many years he had talked of publication, but, as has been shown, it was always a thing of the future. As far back as 1860 the matter of publication had been discussed with his associates, and with the accumulated material of ten years it seemed to his friends that the time had come if ever to bring the work before the world. The late Professor Baird, a firm friend to Mr. Glover during a period of twenty-five years, was very enthusiastic about the matter, and upon several occasions stated his willingness to secure a publisher. But the engraver author was not ready. The work had reached such magnitude that he wished to complete it from his stand-point of completion, and make it an exhaustive illustrated encyclopædia of American entomology, that would find a place in every large library in the land. He did not wish to issue the entire work as a private venture with a probable contingency of great personal pecuniary loss, because it was his dream that it should be published by the Government and be widely distributed gratuitously. The idea had been in his mind for years, and he frequently told me, in conversations of a confidential nature, that in the event of his death he should leave the entire work to the United States Government any way; and at one time he seriously considered the expediency of bequeathing with it a portion of his private fortune to complete it, and to insure its publication in a proper manner after his death.

The talk concerning publication was not without its influence. The preparation of the plates had been known to the entomological public for so long a time, and there was now so little possibility of publishing the work in its entirety in the immediate future, its author foresaw the advantage of, if not the necessity for, a present recognition of the importance and utility of the undertaking, which could best be secured by preliminary publication of some of the plates themselves. It must be admitted, too, that he was actuated toward publication in this manner by a secondary motive—other than a wish to bring to the scientific world a knowledge of the value and immensity of his undertaking—and, prompted no doubt by his desire for the world's golden opinion, a wish to know the exact position his work would obtain in entomological literature.

In 1871 he decided to bring out an author's edition of the plates of Orthoptera, which had recently been increased to thirteen by the addition of new Western material; the new species described by Dr. Cyrus Thomas and material furnished by Mr. Seudder and others forming a considerable portion. An edition of 250 copies, large quarto, was decided upon, and the letter-press was produced a single page at a time at a small printing office in the rear of a Seventh-street book-store in Washington. The work was very incomplete, and does not in the smallest degree represent or carry out the design followed in the preparation of his mass of unpublished "manuscript notes." He does not even fulfill the promise of his introduction.

His table of classification occupies about half a page, and his notes on food and habits of Orthoptera only two pages and a half, the remainder of the text, some five pages, being devoted to "lists of substances injured," and lists of genera and species figured, or, in other words, to the index. This is the published work on Orthoptera. In short, as a work, so incomplete and imperfect, and giving so little idea of what had really been done by Mr. Glover in his twelve or more years of almost incessant labor, that it is to be regretted that he published it in this shape at all. To that extent it placed the author and his great work in a false light, even though the gratuitous publication of a dozen or more of admirable plates alone, with over two hundred figures of correctly named insects in a somewhat neglected order, was a valuable contribution to the entomological literature of America and of the times. Not over 50 copies of the work were bound (in paper), and these were presented to the prominent entomologists and scientific institutions of the country. The remainder of the edition lay piled in the office in sheets for a long time; but was eventually disposed of for waste paper.

Mr. Glover received many flattering letters and complimentary notices following this initiatory publication, and a year later he took steps to bring out a small edition of the Diptera in somewhat the same manner, though rather more full and complete as to the text or letter-press. This, when published in 1874, was a work of 133 pages, printed from stone, upon plate paper, upon one side of the sheet only, the letter-press being a fac-simile of the author's wonderfully clear chirography, and it was accompanied by 10 plates and their explanations. The history of this publication is interesting.

The publication of the Orthoptera had been unsatisfactory even to Mr. Glover, so much so that he contemplated a new edition, and in the Diptera he aimed to produce something more complete and valuable. The preparation of the manuscript was finished in the summer of 1873, and in September it was sent to Dr. Le Baron for his opinion upon its merits, and for revision and correction.

September 14 the doctor wrote Mr. Glover a short note, acknowledging receipt. He states that he has had a couple of days to look it over, and that he is pleased and surprised at the amount of interesting and

valuable matter which it contains. A postscript is inclosed, extracts from which are here produced :

P. S.—Since writing the above note, and before mailing it, I have more carefully examined the plates of Diptera, and am satisfied that they are correct ; correct also, so far as I have examined, in their minute details.

As these plates already extend to twelve in number, in addition to the supplementary plate A and as all the families, I believe, are more or less fully represented, it appears to me that the benefit accruing to students from their immediate publication more than outweighs any advantage which an additional plate could give, unless such plate could be prepared without delay.

My idea is this : The plates now finished being so extensive and so near perfect, and their publication having been so long delayed, I should publish them as they are, or with such additions and corrections as you now have at your command, and leave it for a future edition, if such be called for, to make the work still more extensive and valuable. This is the way the thing strikes an outsider ; but perhaps you, who are behind the curtain, can see difficulties which others can not. * * *

Permit me to refer to one serious inconvenience, not in the execution but in the arrangement of your figures. I mean the indiscriminate mixing, on the same plates, of insects of different families, so that the student wishing to identify a species by a reference to the plates would not know to what part of the volume to turn. If he knew the name of the insect he can refer to it by means of the index ; but if he do not know it he will not know in what part of the book to look for it. This will be most inconvenient in the Lepidoptera where the figures are scattered over so many pages. This was done apparently to economize space, and we shall have to submit to the inconvenience for the sake of the many benefits which we shall be able to derive from the work.

September 25, 1873, Dr. Le Baron writes again as follows :

I have looked through your valuable compendium of Diptera, and have made such suggestions and alterations as appeared to me desirable, and which I trust will meet with your approbation. As it was impossible to examine the work thoroughly, within the time allowed me, and in the intervals of other duties, I have confined my examination mostly to that important portion of the work which lies between pages 92 and 180 of the manuscript. The introductory part, as I understand from the preface, was compiled in a great measure from notes furnished by Baron Osten Sacken, and therefore needs no revision. Next follow the plates, which must be regarded as the special feature of the work. The figures are numerous, neat, pretty, and life-like, and I believe, in the main, correct. As many of them are copied from other authors, their accuracy will almost necessarily vary according to that of the respective authorities. Many of the figures are taken from Packard's Guide, and many of those figures were prepared originally for the American Naturalist. I do not know who was the draughtsman, nor how correct they generally are, as I have never examined them in detail. But one of them which I have had occasion to examine recently, namely, that of *Hyposderma boris*, on page 404, and which you have copied in Plate VIII, 21, is little other than a caricature, as you will see by comparing it with the original, or with Westwood's Figure 3, Plate XIX of Walker's British Diptera, or with your own original figure of the text and variety (VI, 37). * * *

And again, October 15, 1873 :

I have referred in several of my letters to the desirability of having a larger number of copies of your work on Diptera struck off than you contemplated. The idea occurs to me that after 50 copies have been printed at your own expense, an arrangement might be made with the Naturalists' Company to print 1,000 or more additional copies at their expense on shares, they to have a part, perhaps a half, arising from their sale.

I do not know but that it is your intention to have the work stereotyped, so that you can have additional copies struck off hereafter *ad libitum*. If so, all right. But, as I have before said, I can not bear the idea of having all the preparatory labor expended for so small a number of copies. Your work is of a popular and practical character. It gives in a condensed form the greater part of what is known respecting the Diptera, with the additional advantage of being copiously illustrated by figures. The leading idea and aim of the work is that of popular distribution. The 50 copies will of course accomplish nothing of this.

The manuscript was now sent to the publishers of the American Naturalist, in Salem, for an estimate of the cost of printing. In December Mr. Glover learned that Baron Osten Sacken had returned to America, and at once wrote to him as one of his earliest friends in science, and one whose valuable assistance in his dipterological studies he always gratefully acknowledged, asking his advice in the matter. The following is an extract from his letter :

I have just finished and sent to the printing establishment of Putnam & Co., to find out what would be the expense of printing, which, if you approve, I shall do at my own expense, and publish only 50 copies for gratuitous distribution to entomological societies, agricultural colleges, etc. Now, mistrusting my own knowledge on the subject, I fear I may have made some errors, which, taken at the present time, before printing is commenced, may readily be corrected, but which if suffered to appear in print would only lead to future mistakes in nomenclature, etc. I would esteem it a personal favor if you would look the work over and make any corrections you see fit, with your name attached, or without, as you wish. All I want is to get the work out as perfect as I can, and I am willing to bear the whole expense for the sake of diffusing knowledge to those who wish to learn, and have at present no figures to go by. I sent the work to Dr. Le Baron and to Mr. Uhler, who have urged me to have the work published, and, not knowing that you would ever again visit America, I sent the work with all its imperfections on its head to Messrs. Putnam & Co., to put the work through as quickly as possible, as soon as they receive the manuscript from you.

The letter closes with apologies for troubling him, and with the remark that “the work was commenced *entirely at your suggestion*.” The italics are Mr. Glover’s.

In a letter written the first week in January, 1874, he informs Baron Osten-Sacken that he has directed Putnam & Co. to forward the work and says :

You will find in looking over it (the MS.) that I have enlarged my plan so as to illustrate as much of the subject as I could—from foreign specimens when I was unable to procure native. Shall print 250 copies, if you think it worth the trouble : if not, 50 copies are all that I shall distribute.

Mr. Glover was hardly prepared for the reply to the above which was returned a few weeks later ; and though it was received in the same kindly spirit with which it was written, it hurt him cruelly and very nearly caused him to abandon the idea of publication altogether. Baron Osten-Sacken told him frankly that the work was too unequal and too unfinished ; that entomology in the United States had made great progress in the last twelve years ; that the plan of publication which was suitable in 1862 would appear antiquated in 1874 ; and finally that such a publication would be open to criticism and financially a dead loss.

A few weeks later Osten-Sacken wrote a second letter, which is appended:

CAMBRIDGE, MASS., March 6, 1874.

MY DEAR GLOVER: You probably know that I have had some correspondence with Mr. Le Baron respecting your intended publication. I was very sorry to hear from him that you took my letters so much to heart and that you felt discouraged in consequence. The result of my correspondence with Mr. Le Baron was that we came to a perfect understanding as to the main points at issue. We both think that the publication of your plates (with the scientific names appended), in the shape of one or two volumes, would be very acceptable to the public at large. The letter-press, if any, should consist, in my opinion, of the general introduction only to the orders and families, with references, at the end of each family, to the figures belonging to it. But if I were you I would publish the plates at once, without waiting for the letter-press, and give the latter at leisure afterwards. In other words, your work should be for the public at large and not for the few and for the learned societies. As such it will fill a want in the American literature. I even confess that on this point I have somewhat modified my opinion since my last letter, and as well named collections are a rarity your book will, to a certain extent, supply their place. But do not issue each order as a separate work, as the people do not know much about the division of orders yet, and as, issued in this form, the work assumes at once a learned appearance which it should not have. The title should bear the word *Insects*, and not *Coleoptera*, *Orthoptera*, etc., which learned terms upon a title page act as a bugbear to the unscientific.

Believe me always, very truly, yours,

R. OSTEN-SACKEN.

Under date April 10, 1874, Mr. Glover replied as follows:

Should have acknowledged your letter immediately, but was confined to my bed for some days by an attack of bilious intermittent fever. When I read your first letter I felt so much discouraged that if I had had the manuscript in my possession I should have burned it with pleasure and forsworn entomology forever. Indeed I have scarcely opened the book again since it came back from Putnam's. I intended then to publish 50 copies for gratuitous distribution among entomologists and my personal friends, and had saved up the money to pay for its publication; but I was so much disgusted with my own work that I invested in another manner, and *should* I ever publish the plates with merely their names, as you suggest in your second letter, I shall have now to wait until I can save up money to do so. At present, however, I intend to follow your advice and publish the plates as soon as I can with no text, excepting the names and a short introduction, but shall have to refer to your catalogue, as there is no other. I am busy revising and correcting names, notes, and figures of my Orthoptera, and have etched from additional plates from Thomas's new species collected by Hayden and Wheeler. As soon as this is done I shall again commence with the Diptera and prepare the names for publication. Mr. Uhler is assisting me with the Hemiptera, and I intend to figure all the species I can procure during the coming summer.

Remembering the main facts of this circumstance, but not wishing to trust to memory in stating the matter, I have referred to Baron Osten Sacken, who kindly places such portions of the original correspondence before me as are important, together with an explanation, from which the following extracts are taken:

I made the acquaintance of Mr. Glover while I lived in Washington as secretary of the legation of Russia. It was somewhere between 1856 and 1860 [Mr. Glover first met Baron Osten-Sacken in December, 1857.—C. R. D.]. At that time, except Le

Conte and Asa Fitch, there were hardly any working entomologists in the United States; Harris had died a few years earlier. As early as these times Glover was preparing his copper-plates as a record of his collections and observations. I hoped he would issue a volume with plates representing the most common insects, which, *at that time*, would have been very useful in acquainting the public with the principal forms and in starting the subject. But years went by. I left Washington in 1862, and it was only in 1874 that Glover wrote me to ask for my opinion about the publication of his work. * * * However, I had occasion to ascertain afterwards that Glover had fully appreciated my frankness and my kind intention. I am glad that you have undertaken to write a memorial of this amiable and worthy man and sincere lover of nature.

In consequence of the circumstances herein narrated, Mr. Glover modified largely his previous ideas regarding the publication of the Diptera. He decided upon a small edition of 50 copies, and chose for the volume the modest title "*Manuscript Notes from my Journal, or Illustrations of Insects*," and, to carry out the idea more fully, had it printed by lithographic transfer upon stone from his own handwriting.

Apropos of this lithographic fac-simile printing, a characteristic anecdote may be related. As may be inferred his printing bill was considerable. The process necessitated making, with his own hand, a careful copy of each page in transfer ink, and as the steps which followed were purely mechanical he argued that with press and appliances he could easily do the work himself. Making inquiry he learned of a small portable contrivance for the purpose, arranged with a cylindrical stone and which could be obtained at a comparatively low price—less than \$100, I think. So the little printing establishment was purchased and set up in his office in the Department. A very nice page of copy was prepared after everything had been arranged to his satisfaction, directions were duly followed as to the transfer process, ink applied plentifully, and an impression taken.

The professor's face was a study as he took off this first sheet. Not half of the written words appeared on the page, the transferring of the copy not having taken from the stone. Then the printing ink had stuck to the stone in places where the space should have been left white, and altogether it was a very unsatisfactory beginning. Impression after impression was taken with no better success; and then it was decided that insufficient care had been exercised in making the transfer of the original. The next point was to clean the stone. The directions indicated that the cylinder should be placed in a concave appliance, of a material resembling fire-brick, which accompanied the press, and the crank turned until the ink upon its surface had all been removed. Mr. Glover adjusted the stone, grasped the crank, and ground away until patience was very nearly exhausted, when he called in a colored messenger to help him finish the work. Other trials followed, during which the amateur printer lost all patience, and after keeping the contrivance a week or two he prevailed upon the agent to take it back at a large discount from the original cost and a professional lithographer was again employed to do his printing.

In 1876 he brought out the edition of Hemiptera previously referred to, which was uniform with that of the Diptera, and distributed the 50 copies published to very nearly the same persons and institutions to which the former volumes had been sent. The lists of the recipients are preserved with the copies of the two works given to the National Museum.

In all these years of publication he was adding to his plates, to the text of his Coleoptera, Lepidoptera, and Diptera, and began compilations of similar material from original and outside sources in other orders, including the "Arachnida, Crustacea and Annelida, Entozoa, Helmintha," etc. These later volumes, both "rough notes" and "prepared notes," are in the form of scrap-books, made from old public documents, octavo size, and are preserved in the National Museum.* But he gave up further publication, and now devoted a considerable portion of his time to the reproduction, by lithographic fac-simile, of the names to accompany the entire series of plates. These slips of names were prepared and printed for every order excepting the Lepidoptera, including the work on cotton insects; and had his health remained unimpaired he would have finished the names for the set of Lepidoptera also.

In 1878 he issued his last publication, if publication it can be called, an edition of 12 copies of his entire set of 273 plates† with a type-printed

* In addition to his working set of plates, formerly in five quarto volumes, and his published works, complete, the material deposited in the National Museum (before the purchase of his plates was effected) was as follows:

Manuscript notes upon the Coleoptera, Lepidoptera, and Diptera, with alphabetical list of plants or substances injured or destroyed, completed, and systematically arranged (in quarto blank-books).

Hymenoptera, notes, etc., similar to Coleoptera and Lepidoptera, but not completely arranged or systematized, "September, 1862."

The same, "rough notes" and various scraps pasted into old public documents.

Orthoptera, "prepared notes," in three volumes (old public documents).

Hemiptera and Heteroptera, rough notes, three volumes (old public documents).

Neuroptera "rough notes," one volume (old public document).

Cotton insects, plates and clippings from Patent Office Agricultural Reports, and some notes, in a blank scrap-book. Arachnida, etc., and Entozoa, etc., as above, one volume each in old public documents. There is also one volume of original figures, and the volume of the complete work, uncolored, which was presented to Professor Baird by the author, and a few other duplicates.

Not having at hand the original list made by me when the transfer was effected, with Professor Baird's receipt, as the writer acted for Mr. Glover in the matter, the above list was made up while examining the manuscripts in Washington recently (October, 1887).

† The complete set of illustrations comprises 273 quarto plates with 6,179 figures, engraved on copper, covering the following subjects:

	Plates.	Figures.		Plates.	Figures.
Lepidoptera.....	138	2,634	Hymenoptera.....	10	346
Coleoptera.....	49	1,627	Orthoptera.....	18	281
Diptera.....	13	520	Neuroptera.....	7	92
Hemiptera.....	16	464	Cotton and its insects.....	22	215

title-page, a few introductory pages of classification, and catalogues of species with references accompanying each order. The slips of names (save the Lepidoptera) were pasted upon each plate just under the figures, the page being of quarto size. Of these 12 copies, which were of course uncolored, 5 were sent to Europe, and 5 distributed here. Two other copies were sold with his library afterwards. Several copies, in the hands of individuals or institutions, were later on ordered to be colored, the writer having had the work done from Mr. Glover's originals, by a competent colorist. A list of institutions and individuals to whom these sets were sent was made by me at the time of the distribution, but can not now be produced. One other formal publication, issued in 1877, should be mentioned. I refer to the compilation of references to the insects treated in his own and other reports, issued by the United States Department of Agriculture and by the Patent Office, to date of publication. It contains also a list of animal and vegetable substances injured or destroyed by the insects referred to, the entire volume making 103 pages, printed from stone, upon one side of the sheet, in fac-simile, uniform with his other publications. A few sets of his cotton plates were also distributed, bound up with a type-printed title-page and cover.

While upon the history of Mr. Glover's undertaking, it should be stated that among several plans looking toward the ultimate disposition of the work, in the event of its not being published prior to the author's death, there were two plans, at least, entertained by him in the latter part of the centennial year, in which the United States Government was wholly ignored. The first of these, which considered leaving the work to some institution in England, with means to publish it, was hardly seriously contemplated; for being a work upon American insects exclusively, it was not thought at all likely that it would claim the same interest in England as in America. The other plan did receive consideration to the extent of an inquiry of the authorities of Johns Hopkins University, in Baltimore, as to the acceptance of a trust fund to be left for the purpose of promoting the study of entomology. In response to this inquiry Mr. Glover learned that the consent of the trustees could be obtained by President Gilman to the acceptance of a given sum, to be known as the Glover fund, the donor to specify the manner in which he preferred the income to be spent, as follows: Either in promoting investigation, in publishing plates and texts, or in the delivery of lectures. But the plan was never consummated.

At last came his sudden and prostrating illness, in the spring of 1878, and he retired from active labor of any kind.

Regarding the sale of his plates—in January, 1879, during the third session of the Forty-fifth Congress, Mr. Glover first memorialized that body, proposing to transfer to the Government the entire series, together with the text of his entomological work. A special bill providing for the transfer was not introduced, but the memorial was referred to the Senate Committee on Agriculture. Professor Baird took great interest

in the matter, personally appearing before the committee to explain the nature, value, and importance of the work, as well as the fact that the skillful engravings of the copper plates themselves were the work of the professor's own hand, and had involved most unremitting labor for a period of over twenty years. The committee showed little interest in the subject, however, notwithstanding that the memorial was accompanied by another recommending the purchase of the work, and signed by the prominent entomologists of the country, among whom were the United States entomologist, professors of Yale, Harvard, and other colleges, and members of leading scientific societies. During the first session of the succeeding Congress the matter was again brought to the attention of the Committee on Agriculture, and a letter addressed to Professor Baird from the chief engraver of the Bureau of Engraving and Printing was submitted. In this letter it was stated that any skilled engraver would charge \$100 for each of these plates, and if they were engraved by a scientist they were worth more. Senator Davis, of West Virginia, chairman of the committee, suggested that the committee would recommend the purchase at a cost of \$7,500; but the committee took no formal action. This was a great disappointment to Professor Glover, who was now anxious that the work should be purchased by the Government, even at a nominal valuation. At the next session the matter was brought to the attention of the House Committee on Agriculture, and the sum of \$7,500 for the purchase of the work was included in the sundry civil appropriation bill, and finally passed both houses, Professor Riley using his influence towards its final passage. The money became available soon after, and was paid to Professor Glover early in April ensuing the 4th of March upon which Congress adjourned; but by this time he had become quite infirm. The result was very gratifying to him, though he died in September following.

No formal transfer of the plates was necessary after the purchase, as they were already in the custody of the National Museum, having been deposited there by the writer after consultation with Professor Baird at the time when Mr. Glover was first stricken and unable to act for himself.

As to the value of his work, it gave Mr. Glover great pleasure while living to know that it was appreciated by the late Professor Agassiz and leading scientific men of his day. Speaking of the "collections of drawings," Professor Agassiz attests "their excellence and great importance, both in a scientific and economical point of view," and considered "the publication of his observations, and of the delineations of insects injurious to vegetation as most desirable, and likely to be in the highest degree creditable to the United States Government." During the savant's last visit to Washington, while calling upon Prof. John W. Hoyt to talk of the proposed national university, his opinion was asked as to the sort of work that Professor Glover was doing. Agassiz's reply was: "Magnificent! His services are extremely valuable, and

should he ever have occasion to leave the Department he can have a place in the Museum of Comparative Zoology on his own terms."

Many extracts from the letters of entomologists might be here given, showing the estimation in which the work was held, for Mr. Glover had many friends in the scientific world who knew him only by his labors in this, his chosen field. But one extract will be quoted, however, from a letter written to me by Mr. William H. Edwards, when it was first suggested that the Government should purchase Mr. Glover's plates :

DEAR SIR: I am very glad to hear that an effort is making to secure for the country Professor Glover's copper plates of the insects of the United States and his manuscript relating thereto. These materials are invaluable to us, and should Professor Glover dispose of them in England or elsewhere the loss could never be made good. Being an enthusiastic entomologist, as well as artist, these plates have been to him a labor of love, and he has given to them the better part of a life-time, and executes them with the greatest fidelity. His work on the cotton insects is beyond all praise. I know of nothing comparable to it on the range of entomological illustrated literature, and the plates of this work and notes belonging to them are worth, in my opinion, to the country the full sum that Professor Glover requires for the entire lot of plates and manuscript.

In giving my own estimate of this work I must regard it from the stand-point of view that will show the intention of its author. He never proposed to put it forth as a technical work, or as a learned contribution to science, for the instruction or better information of specialists, advanced students, or entomological investigators already possessing large libraries and collections, but he did propose to make it, *when fully completed*, a work of *reference* for all orders of insects in the popular sense of the term, for all who might be seeking general information upon subjects relating to American entomology. In his conception of the work, as in that of his museum plan, but one idea was aimed at—*utility*. It was a favorite word with Professor Glover, and whether his original intention was a work of 80 plates or 300, or the text of 100 or 1,000 pages, his only thought was to make it so simple and so useful that a farmer with no appreciation of entomological science could consult it as he would a dictionary, and learn something of the subject upon which he desired to inform himself. It was to be, in short, an illustrated encyclopedia of economic entomology, and if it had been finished and published in accordance with the author's design, there would be nothing now in entomological literature like it. It certainly would be wrong to judge it by his gratuitous publications. And no one, after fully understanding the scope and design of the work, and examining the great mass of material which represents the labor of twenty years of Mr. Glover's active life, will deny either its utility or its value for the purpose for which it was intended.

Supposing the work had been published in its entirety, and distributed in the manner Mr. Glover proposed it should be, among agricultural societies, to town libraries, etc.: A farmer of average intelligence, we will say, comes, with an unknown insect in hand, to consult it. It would require very slight entomological knowledge to enable him to refer to the list of food plants to learn how many and what in-

sects lived upon the particular farm crop (or plant) which had been injured. This information obtained, with no knowledge whatever of classification, he would be able, by means of the plates, to find the culprit in a very little time, even if the figures were not sufficiently accurate for the determination of fine specific differences. Having learned the species, or even an allied species, reference from plate to text would put him in possession of the main facts in the history of the insect, time of appearance of different stages of the pest, and when and how to combat it. And if the information given was not sufficient he could make use of the references to other works there quoted.

This is, briefly, the manner in which the work was intended to be used, and, as it contains over 6,000 figures of insects more or less injurious (or beneficial) to American agriculture, I may repeat that nothing like it has ever before been attempted, and that its completion and publication would have served to vastly popularize the science of entomology in the United States. But while its production is a marvel of patience, persistence, and self-sacrificing industry, in the twenty years its author was engaged upon it, he might have so systematized the work of its production—calling others to his assistance to relieve himself of the mere drudgery—and so have organized the plan of publication that it would have been completed and placed in every large library of the land while he was yet entomologist of the Department of Agriculture.

The point has been made that some of Mr. Glover's figures are not altogether accurate, if not in some instances badly drawn. The criticism is sometimes a just one, although in their entirety the drawings will bear favorable comparison with similar entomological illustrations of the times. One point must be admitted, that the earlier plates are much better than the later ones, as will readily be seen by careful comparison. That this is due to *two* causes there can be little doubt: Somewhat impaired, or gradually failing eyesight in the first place (the more positive cause), and less care in the second place, through impatience to keep up with incoming material. The completion of two plates a month, "out of office hours," and in the hours of daylight, with all the work of making the drawings before undertaking the engraving, and coloring six or eight sets of the proofs afterwards, should be regarded as expeditious work for a man sixty years of age. Mr. Glover himself regretted having made certain of the plates (early ones in the Lepidoptera), chiefly taken from Smith and Abbott's *Insects of Georgia*, and from a few later works. Some of the far western Orthoptera, too, which were figured from alcoholic specimens, and colored from descriptions, or from other figures, and sometimes from notes made by the collector, are not wholly satisfactory, although readily recognizable by those who have seen the insects in life. Fault has likewise been found with his smaller figures, many of which should have been enlarged to show specific differences in a marked degree, natural size being indicated in the usual manner or by a second figure. All very minute species were properly enlarged, and are, therefore, more valuable.

For purposes of ordinary identification in a general work of reference, as this was intended to be, little fault need be found with the major portion of the series. Of course this presupposes that the plates were to be colored, as it was not the author's idea to issue them in any other way. In fact the very manner of engraving the figures shows this to be the case. In the plates that were published by him, only half the editions were sent out uncolored, and this only because of the great expense attending coloring so many sets by hand—the distribution being entirely gratuitous.

In these days of cheapened processes for multiplied color reproduction this matter is a serious obstacle in the way of future publication of Mr. Glover's plates by the Government. Even if an edition of the plates should be issued, without the text they do not tell the whole story, and the text is not finished; and in several orders the material is hardly systematized or arranged. The plates, if published alone, with only the names, would possess a certain value even if not colored, and it would be better to publish in this manner than not at all. Regarding the question of coloring, if sets of the entire series were distributed gratuitously by the Government, the recipients could well afford to have them colored afterwards at their own expense from the original set. Through combinations of a number of persons, so that a large contract could be given out, the work could be done possibly at \$35 to \$40 per set, which would be cheap for such a complete series of illustrations.

In regard to the published volumes which bear Mr. Glover's name, these are valuable from their very scarcity, and from the fact that they are all he has given us in published form, save the reports which have appeared from time to time in Government publications. As works giving a certain amount of information on two or three somewhat neglected orders of insects they are useful; but from the stand-point of scientific worth they are more valuable as series of named plates than as scientific publications—the often fragmentary and incomplete text giving little hint of the author's years of observation and study in the field and vivarium.

As for the name and fame of the author, a published work comprising an entire set of the plates alone is a sufficient monument to his untiring industry, indomitable perseverance and skill, and to his faithful labors through a period of twenty-five years for the advancement of American entomological science. He wished to do more, but through the limit set upon human endurance and existence he fell just a little short of carrying out his great purpose. He did not strive for fame through any contributions to the vast store-house of technical knowledge, or the dry-dust records of closet investigation that he might have made, nor did he ever wish to be considered an authority. But he early realized the difficulties which beset the way of the student of nature, and that other student of practical rural economy, in obtaining a knowledge of the insect forms about them, at a time when there were few books and fewer named collections, and set to work to remedy the matter as far as he was able.

THE GLOVER MUSEUM.

As has been stated in the biographical sketch of Mr. Glover's life, the museum scheme was contemplated many years before it was realized. Indeed its first inception dates back prior to 1850, before he had left his home on the Hudson. Regarding his collection of fruit models he writes in 1866:

The design is to obtain from each State samples of the various fruits which have been tried and proved; to have them modeled here, retaining one copy to be added to the national collection, and returning duplicates (and matrices), correctly named, to each agricultural society.

Fifteen years before this, in 1851, he made the proposition to the Massachusetts Horticultural Society to do this same thing, and some specimens were furnished, made from fruits sent to Mr. Glover by members of the society. Allusions to "the specimens for the New York State Society," in a letter written at this period, also shows that the idea was a very old one with its author. And all these early attempts at exhibition tended directly towards the museum idea.

The first attempt to fully carry out the scheme was made in 1854, in the single room which at that time constituted the Patent Office Bureau of Agriculture; the fruit models being the chief display. At this period they were his private property, though a year or two later the proposition was made to dispose of them to the Government for \$10,000. The precise facts regarding early legislation on the subject can not be given. But in 1858 we learn that Mr. Glover had seen a number of gentlemen, whom he names; that "everything appears favorable;" and "that the bill" will be put on "as an amendment." Then we learn of his showing the fruits to members of Congress, who approved of the idea, and promised to vote for the purchase. Meanwhile he leaves Washington for the field, and while pushing his investigations he learns that the bill has been defeated by "Letcher and Marshall," of Virginia. This characteristic entry follows: "Will remember them for it. Intend to resign in the fall, and offer to South Carolina or Maryland." As a matter of history the bill was passed, though Mr. Glover did not receive the money, through "misappropriation of funds." In 1867, however, the purchase was consummated, the sum of \$10,000 being appropriated for the purpose, Hon. J. W. Stokes, then acting Commissioner of Agriculture, having been instrumental in effecting its passage.

To go back again to the year 1856, he makes statements on the subject, in a letter to his cousin, which throws interesting light on the museum scheme. He says:

I ask \$10,000 for the whole, with the proviso that I work six years to finish the grand undertaking of modeling all the fruits, esculent roots, etc., of the United States, and label them with the name, synonym, habit, soil, etc., so as to form the nucleus of a grand National Agricultural Museum. How do you like the plan?

The difference to Mr. Glover between selling his fruits in 1856 and in 1867 was, that before the war he would have received this money in gold, whereas he received it in a "depreciated currency;" and, in addition to the fruit models, gave a collection of 600 specimens of birds, which he had subsequently prepared and brought together, at considerable expense of money and time, while at the Maryland Agricultural College. Even while connected with this institution, his labors, still in the line of the practical and utilitarian, were directed towards the acquirement of a collection. Mr. Glover was a skillful taxidermist, and was a capital shot, notwithstanding the peculiarity of his eye-sight; and as he tramped over the adjacent country, cane-gun in hand, using it also as a walking-stick, he doubtless appeared more as a rural gentleman than the enthusiastic naturalist that he was.

In August, 1864, the new museum was founded in the rooms of the recently established Department of Agriculture. At this time the models (some 3,000 in number) and the collection of birds above mentioned constituted the major portion of the cabinet. This was soon augmented by donations, solicited or otherwise, or by occasional purchases, and a mass of material was very soon gotten together representing, in one way or another, nearly every portion of the country. Insects, birds, plants, and botanical specimens, cereal products, fibers, and the products of industrial art and manufacture were all included in the collections, and the museum was fairly established. From this time forward, up to and including the centennial year, its growth was steady and rapid.

Regarding the plan or scheme of arrangement, which was most complete in detail, it is not necessary to go into particulars here, as it is fully described on page 27 of the Annual Report of the Department of Agriculture for the year 1866.

Briefly, the museum was to be embraced in three divisions—a general, State, and economic. The first he was to illustrate by complete series of specimens of each of the various agricultural products from the seed, through all stages of growth and after preparation for human use, up to the highest range of manufacture. In the State division would be shown the classified products of each State and Territory, including minerals, soils, vegetable products, and manufactures; while in the economic division would be displayed the commercial products of the vegetable kingdom from every portion of the world. It was a grand scheme, but too immense to be fully carried out in the cramped quarters assigned

to it, and in the days of ridiculously small appropriations. And here pardon a digression. In one of the biographical sketches of the man, which appeared at the time of his death, it is said that "during his entire service he never asked for special appropriations for the pursuit of investigations in any particular interest." This is true, but while he never "asked" for appropriations—*i. e.*, by persistent personal labor with committeemen—he never lost the opportunity to explain to Congressmen or other visitors of influence the benefits to be derived by American agriculture in the establishment of such a museum in Washington; and he always closed with a tersely-put statement as to the ridiculously small sums of money that were available from the annual appropriations with which to carry on the work. And upon one occasion, some years after the establishment of the museum, he made such an impression upon an enthusiastic committeeman who was visiting the collections that the sum of \$3,000 was shortly afterward appropriated for the museum, to be spent under Mr. Glover's special direction. It nearly took his breath away, and, as his assistant, I well remember how hard it was to get him to use all of the money, as any unexpended balance at the end of the fiscal year would be turned back in the Treasury, the reluctant purchase of a microscope *nearly* using up the amount remaining on hand the last of June.

It was natural for him to talk the museum scheme to all who would listen. He believed in his plan, thought over it, worked for its perfection, confidently believing in its ultimately attaining the fullest realization of success. The two rooms in the Patent Office were soon filled to overflowing; and when the designs were being made for the new building to be erected for the Department of Agriculture an exhibition hall, 50 by 100 feet in dimension, was contemplated, which it was thought would be ample for the purpose. This was occupied in the fall of 1868, twelve walnut cases having been provided for the reception of the various collections at that time brought together. But even in the new hall the "plan" was hardly fulfilled in the arrangement. The "State division" was represented by a single case of California products, the other two divisions not being distinctively indicated, the entire museum being at the same time "general" and "economic," as its specific collections were as yet small and very incomplete.

As a man of deep originality and thought may make a wonderful discovery or produce a valuable invention, and yet find himself lacking in that worldly knowledge which would enable him to apply it with the least difficulty to the uses of every-day life, so it was to a certain degree with Mr. Glover in relation to his admirable museum scheme. Stronger as an originator, or an investigator, than as an *organizer*, he lacked in a measure executive ability. He was able to outline and perfect a splendid system, but unable to carry it out save as he might do so through the untiring labor of his own hands. This was the one drawback in the preparation of his great work on entomology; and it showed itself in the

building up of his museum in a marked degree after it had reached a certain point in its growth. The fact may be stated that in carrying out the museum scheme it was not developed beyond this certain point, and the suggestion is offered that the theory of its arrangement may have interested him more than the thing itself; for, with his devotion to his work on entomology, which was an all-absorbing interest at this period, he could not have given his time and thought to both. It was the *illustration* of the conception of the plan, and not the museum as a whole, that was almost daily presented to its visitors.

For example: The California case was always inspected to illustrate the State division and the arrangement of its minerals, its vegetable products, and its manufactures explained. Turning to the collections of fruit in other cases near, the model of the Baldwin apple was invariably exhibited, showing its manner of growth in various sections of the country, thus demonstrating the localities where special fruits thrived best. Stepping to another case, the bluebird was always pointed out, with the distinctive mark upon its perch showing that it was a friend and not a foe to the farmer; and a little box of insect remains from its stomach, by its side, furnished the proof of his statement. Flaxseed in variety was shown in another case, illustrating the "general" museum, together with the fiber in various stages of growth and manipulation to the most delicate linen fabrics, and in the same manner the seed, oil, and oil cake.

The scheme was most complete and admirable, reflecting the greatest credit upon its originator, and if carried out would have made it one of the grandest economic museums in the world. But it would have necessitated a building larger than the entire Department of Agriculture, and the outlay of many thousands of dollars, with the one drawback that in its State division there would have been endless repetition of the same thing, unless somewhat modified. Mr. Glover appreciated this fully, and there was never an attempt, beyond the points of illustration noted, to make it other than an economic museum of agriculture on the simplest possible basis of display. These statements are made to explain in a measure why so valuable and utilitarian a scheme of arrangement was never fully completed.

As an economic museum or "object library" the collections increased, at first slowly, then rapidly, so rapidly in fact that it was difficult to supply case-room as fast as the specimens came in. It literally outgrew the long entertained plan of arrangement, and as Mr. Glover became more and more absorbed in his entomological work he finally threw the greater part of the responsibility of the museum from off his shoulders altogether, his assistants having charge of and carrying on the work in its several branches, while he assumed merely nominal control. By this time the collection of fruit models had been greatly augmented by Prof. William H. Seaman, who had charge of this branch, as well as the microscopic work of the Division, a large series of the

principal vegetables also having been added; while a regularly appointed taxidermist, Mrs. Teresa Drexler, made considerable additions to the collections of birds and poultry. Miss Caroline C. Moulton was museum attendant.

Then the preparations for the Centennial Exhibition of 1876 were inaugurated, the supervision of the work of getting up the museum exhibit devolving upon the assistant entomologist,* who, co-operating afterwards with Professor Baird, was enabled to almost double the collections of the department from foreign exhibits, necessitating the erection of a gallery on each side of the museum hall.

Mr. Glover had by this time so far lost interest in the museum, being now wholly absorbed in his entomological work and its publication, that when the acquisition of this great mass of material necessitated a better classification and arrangement of the museum display the formulation of a new plan of arrangement was left entirely to the writer. The classification which was then devised is published at the end of the entomologist's report in the annual volume for 1877, pages 118 to 148,† in a special report made to Mr. Glover.

It may be stated that the scheme of arrangement set forth in this published classification was closely followed in the reorganization which shortly followed.

The museum was now (1877) at the zenith of its importance and usefulness, and shortly after its decline began. The first calamity which occurred to it was the loss of many of its large and valuable collections gathered at the Centennial, which, for want of a few hundred dollars worth of display bottles and other material suitable for their exhibition, asked for and repeatedly refused, remained stored in the garret above the museum hall. Through the officiousness of the property clerk of the department, appointed by Commissioner Le Duc, or by the Commissioner's order, this mass of material was either sold to a junk dealer or thrown on a rubbish heap, according to its market value at "junk" prices, and thousands of dollars' worth of valuable museum material wasted and destroyed. Then followed Mr. Glover's retirement from active duty, and as the assistant entomologist shortly after resigned, and other changes had occurred in the museum corps, the museum was practically left without care, as no regular curator was appointed for several years. Dr. Vasey was given nominal charge for a time, but his own duties as botanist were sufficient to occupy his whole attention.

The remainder of the story is briefly told. A wooden exhibition building had been erected in one corner of the department grounds for the display of railroad exhibits and other similar exposition displays. More

*See Agricultural Report for 1876, p. 17.

†The entomologist reluctantly incorporated this museum report and classification into his own report, signing his name to the two documents in one to avoid running counter to the whims and absurd prejudices of the gentleman who was then Commissioner of Agriculture. This statement is made in simple justice to the author of the report.

office rooms were needed in the department building than its cramped quarters afforded, and in time the space in the splendid museum hall was encroached upon. The collections thus displaced were removed to the exposition building referred to above, though some, as the fibers and birds and a few of the more valuable economic collections, were transferred to the National Museum, where they are carefully preserved, though as yet not placed on exhibition. As to the remaining portion of the "Glover Museum," it is pretty nearly as it was left ten years ago, save that many of the collections of specimens have suffered from want of care and attention, and that the museum hall is now given over to other uses, for the specimens, those that were worth further preservation, were transferred to the exhibition building mentioned during the winter just passed.

To conclude: The scheme of the museum, as contemplated by Mr. Glover, was original and unique, however some of its special features may have been suggested by European museums, and it is to be regretted that it could not have been perpetuated and preserved in the original space expressly designed for its accommodation, and where its founder and father labored for its establishment and watched so long its growth and development.

And what more remains to be said? The influence of such a man as Mr. Glover is shown to have been made itself felt, though the ultimate outcome of his schemes for the diffusion of knowledge among his fellow men did not reach the perfect realization that he had dreamed. "I confess I have no idea how one man had the power alone to accomplish so much work in such a superior manner," Prof. Hagen once wrote of him. He could not have accomplished more, for he did that which his hands found to do with all his might while his strength lasted, and then he rested from his labors.

BIBLIOGRAPHY.

Mr. Glover's entomological writings are confined almost exclusively to his reports published in the *Annals of the Patent Office*, and the *United States Department of Agriculture*, and the few published works which bear his name. His earliest writings, as far as I have been able to discover, date back to the fall of 1853, and, with one exception, relate to pomological subjects rather than to entomology. He wrote occasionally for the *Fishkill Standard*, usually in a satirical vein, holding up to ridicule some local abuse, though not, as far as I know, upon entomological subjects. It is also surmised that he wrote a series of articles for *The States*, published in Washington before the war, in which the shortcomings of a public official were pointedly reviewed. If there were scientific articles written at this period of his life other than his Patent Office reports, with a single exception, I do not know of them, and his personal scrap-book does not reveal them. It is a known fact that he could not be induced to contribute to current literature during the period of his labors in the Department of Agriculture, though he was frequently urged to do so.*

Throwing out, therefore, all titles which are known to represent mere republications from his reports, the record is reduced to the following titles, which, as far as I have been able to learn, are the published articles, works, or writings of Townsend Glover.

1. "**Popular Fallacies.**" *American Agriculturist*, November 9, 1853. Signed "G."

A short article on the many impracticable insect remedies which go the rounds of the agricultural press, year after year, unproven and unchallenged.

NOTE.—At the same period, and in the same journal, the following general articles were published over the same initial: *Planting Shade Trees along Highways and Railroads*, Nov. 23, 1853; *Pomological Dream*, Nov. 30, 1853; and *Pomological Realities* (on pear culture), Dec. 23, 1853.

2. **Insects Injurious and Beneficial to Agriculture.** Report of the Commissioner of Patents for 1854. *Agriculture*. p. 59-89. Illust. by six plates engraved on stone by the author.

A paper on insects injurious to the cotton plant, wheat, and the grape-vine; and on the plum curculio, codling-moth, and peach-borer, closing with a short account of some of the common species of beneficial insects.

* I find in one of his scrap-books a lengthy communication, clipped from some newspaper unknown to me, which must have been a published official reply to some correspondent of the Department. It is omitted from the bibliography.—C. R. D.

3. **Report on Insects.** Report of the Commissioner of Patents for 1855. Agriculture. p. 64-119. With 48 wood-cut illustrations, from drawings by the author.
A report on insects frequenting the cotton plant; insects upon the stalk, leaf, terminal shoots, flower, boll, and rotted bolls; insects found in the cotton fields not injurious to the crop, and insects beneficial to cotton. Also contains a report on insects injurious and beneficial to the orange tree—the orange scale.
4. **Paper upon Entomology.** Read before the meeting of the United States Agricultural Society. Dated Jan. 11, 1856. National Intelligencer. Date of publication cannot be given. (Republished in Fishkill Standard.)
5. **On Destroying Injurious Insects.** American Agriculturist, Oct., 1856. Vol. 15. p. 304.
6. **Reports on Orange and Cotton Insects.** Report of the Commissioner of Patents for 1858. Agriculture. p. 256-272.
Report on insects frequenting the orange trees of Florida, including remarks on the orange tree by D. J. B. (Browne). Also contains report on insects injurious to the cotton plant in Florida. Notes on cut-worms and the cotton-stainer.
7. **The Hang-Worm.** Report of the Commissioner of Patents for 1859. Agriculture. p. 551-554. 1 Figure.
An answer to a correspondent of the U. S. Patent Office, giving the history of "*Oiketicus*," (*Thyridopteryx ephemeraformis*).
8. **Report of the Entomologist.** Annual Report of the (U. S.) Commissioner of Agriculture for 1863. p. 561-579.
Contains notice of the establishment of the Agricultural Museum, and article on the habits of the principal species of Coleoptera injurious to agriculture.
9. **Report of the Entomologist.** Annual Report of the (U. S.) Commissioner of Agriculture for 1864. p. 540-564.
A short report on the Museum, followed by a description of the habits of principal injurious species of Orthoptera, Neuroptera, Hymenoptera, Lepidoptera, Heteroptera, Homoptera, and Diptera.
10. **Report of the Entomologist.** Annual Report of the (U. S.) Commissioner of Agriculture for 1865. p. 33-45.
A report on the progress of the Museum, followed by a brief synopsis of habits of birds examined and placed in the Department since the last report.
11. **Entomological Exhibition in Paris.** Annual Report of the Commissioner of Agriculture for 1865. p. 88-102.
Treats of entomology on pages 88-94, 101-102; the rest is on agricultural museums, botanical gardens, the gardens of acclimation in Paris, and the collection of the Zoological Society of London. Habits of European injurious insects compared with those of related American insects; habits of European beneficial insects; silk culture noticed; grand gold medal awarded to Glover for his work on entomology.
12. **Report of the Entomologist.** Annual Report of the (U. S.) Commissioner of Agriculture for 1866. p. 27-45.
I. Contains brief statements regarding the insects which have been reported on by the division for the year. II. Contains an economic paper on insects and their uses—chiefly relating to the products of insects, as honey, wax, cochineal, etc.
13. **Injurious to Cotton Plants.** Monthly Reports (U. S.) Department of Agriculture for 1866.
A series of articles on the most injurious of the cotton insects, as follows (illustrated):
No. 1. June. p. 239-241.
No. 2. July. p. 282-285.
No. 3. Sept. p. 331-335.
No. 4. Oct. p. 377-378.
No. 5. Nov. and Dec. p. 421-424.
14. **The same.** In Monthly Report for 1867. No. 6 of the series, January, 1867. p. 21-23.

15. **Report of the Entomologist.** Annual Report of the (U. S.) Commissioner of Agriculture for 1867. (p. 53-76.) 16 illustrations.
A report on the insects most injurious to agriculture during the year, that had been received by the Entomological Division.
16. **The Potato Beetle.** Monthly Report Department of Agriculture for January, 1868. p. 22.
17. **The Food and Habits of Beetles.** Annual Report of the (U. S.) Commissioner of Agriculture for 1868. p. 78-117; and 114 outline illustrations.
Part I. An article on the food and habits of the more common species of Coleoptera. Part II. An alphabetical list of the principal animal and vegetable substances either frequented or injured by beetles, with the names of the beetles frequenting them.
18. **Report of the Entomologist.** Report of the (U. S.) Commissioner of Agriculture for 1869. p. 60-64.
A very brief report, relating entirely to the Museum of the Department.
19. **Report of the Entomologist and Curator of the Museum.** Annual Report of the (U. S.) Commissioner of Agriculture for 1870. p. 65-91. 59 illust.
A record of the work of the Entomologist Division for the year, including new facts relating to injurious insects from other sources.
20. **Entomological Record.** Monthly report of the Department of Agriculture for 1871. p. 332-335.
Notes on the Colorado beetle, the chinch-bug, ravages of grasshoppers, thrips, etc.—[These notes, together with the records published in ensuing monthly reports for several years, were for the most part embodied in the annual reports of the Department, prepared at the time of or after their publication in this form.]
21. **On the Grape-Vine Hopper.** Monthly Report for October, 1871. p. 403.
22. **Entomological Record.** Monthly Report for November and December, 1871. p. 477.
On twig-girdlers, strawberry insects, etc.
23. **Report of the Entomologist and Curator of the Museum.** Annual Report of the (U. S.) Commissioner of Agriculture for 1871. p. 69-88. 23 illust.
A record of the principal insects reported on by the Department during the year.
24. **Destructive Grasshoppers in California.** Monthly Report of the Department of Agriculture for January, 1872. p. 22.
25. **The Utah Cricket.** Monthly Report, February, 1872. p. 74.
26. **The Cabbage Moth.** Idem. March and April, 1872. p. 137.
27. **A New Grasshopper.** Idem. May and June, 1872. p. 215.
28. **Entomological Record.** Idem. July, 1872. p. 304-307.
29. **Entomological Record.** Idem. August and September, 1872. p. 366-369.
On peach-tree insects, and misc. insect injuries.
30. **Entomological Record.** Idem. October, 1872. p. 438-439.
On the army or "snake-worm" insect injuries.
31. **Entomological Record.** Idem. November and December, 1872. p. 497-499.
On a large grasshopper and insect injuries.
32. **Report of the Entomologist and Curator of the Museum.** Annual Report Commissioner of Agriculture for 1872. p. 112-138. 26 illustrations.
I. Report on the entomological work of the division for the year, with brief history and habits of the insects recorded. II. A paper entitled "Notes on the Diptera, with the principal remedies in use for injurious insects in this order."

33. **Illustrations | of | North American Entomology.** | (United States and Canada)—by Townsend Glover, Washington, D. C. | Orthoptera. | Washington, D. C. | 1872. Large quarto; text, 11 pp. 13 plates with names.

This work, the only one printed from type, contains: An introduction, arrangement of families, notes on food and habits of orthoptera, parasites, list of substances injured by orthoptera, lists of genera and species figured, list of desiderata and errata. 250 copies printed; 50 distributed gratuitously, the remainder of the edition having been destroyed.

34. **A Vindication of the Entomological Division of the U. S. Department of Agriculture.** Private print, 1872. p. 6.

Published in reply to statements made in "The Department of Agriculture, its History and Objects," a pamphlet issued, 1872, by the chief clerk of the Department. Gratuitously distributed.

35. **Entomological Record.** Monthly Report of the Department of Agriculture, for 1873. p. 29-31.

Notes on the apple-twig borer, the rose bug, plum insects, and other insect injuries.

36. **The Tobacco-worm.** Idem. April, 1873. p. 164.

37. **Entomological Record.** Idem. May and June, 1873. p. 237-238. Notes on the apple-twig borer and Colorado beetle.

38. **Entomological Record.** Idem. July, 1873. p. 345-347. Notes on corn insects, the grape-vine root louse, trap-door spider, Colorado beetle, luminous larvæ, etc.

39. **Entomological Record.** Idem. August and September, 1873. p. 426-427. On Paris green, the Phylloxera, etc.

40. **Entomological Record.** Idem. October, 1873. p. 496-497. Notes on grape-vine borers and insect injuries.

41. **Entomological Record.** Idem. November and December, 1873. p. 571-578. Notes on the phylloxera, the Colorado potato beetle, protection against cotton moths, *Xyloryctes satyrus*, and insect injuries.

42. **Report of Entomologist and Curator of the Museum.** Report of the U. S. Commissioner of Agriculture for 1873. p. 152, 169. 10 illust.

A brief report on the injurious species of insects reported during the year with conclusions, etc., relative to the use of Paris green and other poisons in combating cotton insects.

43. **Entomological Record.** Monthly report of the U. S. Department of Agriculture, for 1874. p. 43-45.

Notes on the *Phylloxera*, Paris green, the cotton caterpillar, &c.

44. **Entomological Record.** Idem. April and May, 1874. p. 221-222. On luminous beetles, and poke-root as an insecticide.

45. **Entomological Record.** Idem. July, 1874. p. 324-330. On Colorado potato beetle, and notes on insect injuries.

46. **Entomological Record.** Idem. August and September, 1874. p. 373-376. Notes on insect injuries.

47. **Entomological Record.** Idem. October, 1874. pp. 428-431. Experiments with *Phylloxera*, the cotton worm, etc.

48. **The Grape-root Gall-louse.** Idem. November and December, 1874. p. 506-7.

49. **Report of Entomologist and Curator of the Museum.** Report of the United States Commissioner of Agriculture for 1874. p. 122-146. 20 illust.

PART I. A brief report on the Colorado potato beetle and other insects, giving the new facts of the year. PART II. An economic paper on the Orthoptera.

50. Manuscript Notes from my Journal | or | Illustrations of Insects | Native and Foreign | Diptera | or | Two-winged Flies. | Washington, 1874.

Written by Townsend Glover. Transferred and printed from stone by Jas. F. Gedney. 4to. pg. III, plates I-XII, pl. A (each with a page of explanation) pg. 120, printed only on one side of the sheet. Only 45 copies printed for gratuitous distribution.)

- (a) Introduction, p. I-III. (b) Figures of about 340 imagoes, 160 young, 30 habitations, and numerous details of about 400 species, pl. I-XII. (c) Anatomical details of 86 genera pl. A. (d) Arrangement of families, p. I. (e) Alphabetical list of the families and genera of Diptera mentioned in this work, with synonyms, habitat, food, etc., p. 2-59. (f) Alphabetical list of predaceous or parasitic Diptera, the larvæ or perfect flies of which destroy other insects, p. 60-62. (g) Alphabetical list of vegetable and animal substances, etc., inhabited, injured, or destroyed by Diptera, p. 63-78. (h) Alphabetical list of insects of other orders either destroying Diptera or destroyed by them, p. 79-85. (i) Alphabetical list of names of authors, and of authorities quoted, p. 86-89. (j) Abbreviations used in this work, p. 90. (k) Alphabetical list of some of the genera, etc., of Diptera, with derivation of names, p. 91-93. (l) Alphabetical list of the species of Diptera, and other orders, fungi, etc., with derivation of names, p. 94-100. (m) Supplement. 1. Remedies, p. 101-111. (n) Alphabetical list of insects, etc., mentioned in Report on Remedies, p. 112. (o) Synoptical tables (of divisions and families), p. 113-118. (p) Definition of terms, p. 118. (q) Addenda, p. 119-120. (r) Notes, p. 120.

51. Recent notes on the Phylloxera, from Foreign Sources. Monthly Report U. S. Department of Agriculture for January, 1875. p. 40.

52. On Beneficial Insects. Idem. April, 1875. p. 175-6.

53. Entomological Record. Idem. May and June, 1875. pp. 221-230. On cutworms; Phylloxera in Austria, the same in France; locusts, etc.

54. Insect Injuries. Idem. July, 1875. p. 307-310.

55. Insect Injuries. Idem. August and September, 1875. p. 367-370.

56. Entomological Record. Idem. October, 1875. pp. 442-445. Notes on the chinch-bug and Colorado beetle.

57. Report of the Entomologist and Curator of the Museum. Report of the (U. S.) Commissioner of Agriculture for 1875. pp. 114-136. 63 illust.

PART I. An Economic paper on the "Heteroptera or Plant Bugs." PART II. Remedies reported to be serviceable in destroying insects in the Suborder Heteroptera or plant bugs.

58. Insect Injuries. Monthly Report of the U. S. Department of Agriculture, 1876. p. 245.

59. Insect Injuries. Idem. August and September, 1876. p. 333-336.

60. Manuscript Notes from My Journal | or | Illustrations of Insects | Native and Foreign | Order Hemiptera | suborder Heteroptera | or plant-bugs. | Washington, D. C. | 1876.

Written and etched by Townsend Glover; transferred and printed from stone by J. C. Entwistle, 1876. (2)+2+10-133 p. (p. 1-57*bis*, p. 58-132), 10 pl. (pl. 1-9 colored), printed only on one side of the sheet. (Only 53 copies printed, for gratuitous distribution.) Title; copyright. (a) Introduction, p. 1-2. (b) About 325 figures of about 257 imagoes, 19 young and numerous anatomical details of about 240 species, pl. 1-10, each pl. with a p. of explanatory text. (c) Arrangement of families, etc., of the Heteroptera, or plant-bugs (Burmeister's arrangement (1835), p. 1-6, p. 16; Westwood's (1840), p. 7-9, p. 16; Amyot and Serville's (1843), p. 9-12, p. 16; Douglas and Scott's (1861-1865), p. 12-15, p. 17), p. 1-17. (d) Alphabetical list of the families and genera of Heteroptera mentioned in this work with synonyms, habits, food, habitat, etc. (includes, with others, all the species mentioned in Say's works, with the names of the genera to which they have more recently been removed), p. 18-73. (e) Alphabetical list of predaceous or parasitic Heteroptera, the larvæ, pupæ, or perfect insects of which destroy other insects, p. 74, 75. (f) Alphabetical list of vegetable and animal substances frequented, injured, or destroyed by Heteroptera, p. 76-83. (g) Alphabetical list of insects of other

orders either destroying Heteroptera or destroyed by them, p. 86, 87. (h) Alphabetical list of the names of the authors and of authorities or societies, etc., referred to in this work, p. 88-91. (i) Abbreviations, etc., used in this work (with a diagram of three French inches divided into lines), p. 92. (j) Remedies reported to be serviceable in destroying insects of the suborder Heteroptera or plant-bugs, p. 93-96. (k) Alphabetical list of (some principal) sections, families, and genera of the Hemiptera, Heteroptera, with derivation of names, etc., etc. (compiled from the works of various authors, omitting many synonyms, and referring the genera to the families of Amyot and Serville's classification), p. 97, 112. (l) Alphabetical list of species, of the Hemiptera, Heteroptera (with translation of the names and referring the synonyms to their proper genera), p. 112-118. (m) Genera as arranged in the entomological cabinet of the Museum of the Department of Agriculture, Washington, D. C., 1876 (with reference to the pages on which the genera are mentioned in Amyot & Serville's *Histoire naturelle des Hemipteres*, Paris, 1843), p. 119-123. (n) Extracts from the list of Hemiptera, of the region west of the Mississippi, including those collected by the Hayden explorations of 1873, by P. R. Uhler, Baltimore, Md., Washington, D. C., January 1876 (giving Uhler's arrangement of the "families, &c.," and referring to the pages on which the genera are mentioned in that work, (see Rec. No. 568), p. 124-137. (o) Notes of the habits of the Heteropterous insects, with the latest changes in the nomenclature, position, and classification of the various families, subfamilies, genera, and species (taken from Uhler's List (see Rec. No. 568), and referring to the pages of that list), p. 128-131. (p) Errata and addenda, p. 132. (q) List of (4+) societies and individuals to whom a copy of this work has been sent (1876), p. 132.

61. Report of the Entomologist and Curator of the Museum. Report of the U. S. Commissioner of Agriculture for 1876. pp. 17-46. Illust., p. 59.

- I. Contains report of Chas. R. Dodge on the Museum exhibit at the Centennial Exhibition.
- II. Economic paper by the Entomologist on the Homoptera.

62. Report of the Entomologist and Curator of the Museum. Report of the Commissioner of Agriculture for 1877, pp. 89-148, Plates V, Figs. 100, reproduced from the authors' engravings of Hymenoptera.

- I. Economic paper on the Hymenoptera in relation to American Agriculture; II. A report on the Museum Division, with a systematic classification for economic museums, prepared by Charles R. Dodge.

63 Manuscript Notes from my Journal | or | **Entomological Index** | to names, &c., | in | **Agricultural Reports** | with list of | **Vegetable and Animal Substances Injured or Destroyed by Insects** | Washington, D. C., | 1877. 103 pages, quarto. Written and etched by Townend Glover, and printed on stone.

50 copies were printed for gratuitous distribution.

64. Illustrations | of | **North American Entomology** | in the orders of | **Coleoptera, Orthoptera, Neuroptera, Hymenoptera, Lepidoptera** | **Homoptera and Diptera** | By Townend Glover | Washington, D. C. | 1878.

The entire set of 273 plates, with names of species on each plate in every order but Lepidoptera. Contains, also, arrangement of families, compiled from various authors, in each order, with alphabetical lists of families and alphabetical lists of species, with references to plate and figure. Twelve copies only were printed for gratuitous distribution, chiefly to institutions in this country and in Europe. The series also contained the 22 plates of cotton insects though not so stated on the title page. This was Mr. Glover's last work, issued only a short time before he was forced to cease his labors and to end his active connection with the Department of Agriculture.



676-45

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 19.

AN ENUMERATION
OF THE
PUBLISHED
SYNOPSIS, CATALOGUES, AND LISTS
OF
NORTH AMERICAN INSECTS;

TOGETHER WITH OTHER INFORMATION INTENDED TO ASSIST THE
STUDENT OF AMERICAN ENTOMOLOGY.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., May 15, 1888.

SIR: I have the honor to submit for publication Bulletin No. 19 of this Division, being an enumeration of the published synopses, catalogues, and lists of North American insects; together with other information to assist the student of American Entomology.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

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SYNOPSIS, CATALOGUES, AND LISTS OF NORTH AMERICAN INSECTS.

INTRODUCTION.

Inquiries regarding the works most useful for the determination of our native insects, as also about the most useful general works of reference, are among the most constantly recurring ones received by the Entomologist; but satisfactory and short replies are in most instances impossible, for the reason that the information is not contained in a few comprehensive works, but is scattered through many different periodicals and other publications. A complete list of such works, even of those pertaining to a single Order of insects, is too long to be given in an ordinary letter, and to obviate the difficulty experienced in such correspondence this bulletin has been prepared.

It was not our intention to compile a complete bibliography of the classification of North American insects, but to give briefly the references to such works and papers as are most useful for the identification of our insects. Thus, we originally planned to give only the titles of monographs or synopses of families or subfamilies and to reject all papers which contained disconnected descriptions of new species, or revisions and synopses of isolated genera. But while preparing the bulletin it was felt to be advisable to include smaller synoptic papers. For instance, several large families, *e. g.*, the Scarabæidæ among the Coleoptera, have recently been quite carefully revised, but the literature is in the form of synopses of single genera which, in their aggregate, form a more or less complete monograph of the whole family. In this case either these smaller synopses had to be mentioned in this bulletin or the whole family had to be omitted.

On the other hand, many of the monographs here mentioned are antiquated, so as to be of little value at the present time; or they are monographs comprising the genera and species of all countries, and difficult for the student of the American fauna to use, from the fact that the descriptions of the American genera are almost lost amongst the mass of foreign material.

It were futile to attempt to discriminate in such an enumeration between the more useful and the more or less useless, but as a rule we would recommend to the student to consult rather the later than the

older publications. Unfortunately there are marked exceptions to the rule; as a few of the latest synoptic and descriptive papers by the younger authors are most insufficient and unsatisfactory. We have added a list of the special works on Economic Entomology, and also of those published by the U. S. Entomological Commission and by the Department.

There are a good many comprehensive classificatory works on European insects, but the almost complete absence of such works in this country is a great bar to the progress of entomology and is the inevitable outcome of the immense mass of material to be worked up and of the comparatively small number of workers in monographic entomology. As will be seen from the contents of this bulletin, the publications of this kind even in Orders most worked up, as in Coleoptera and Lepidoptera, are greatly scattered; while in the less popular Orders comparatively little has been done. Yet with the many earnest workers now in the field we may hope to see this present want met at no very remote period, and if the present bulletin should prove of temporary service it will not have been prepared in vain, though intended chiefly to relieve the Division of a great deal of letter-writing.

The preparation of the titles was originally placed in charge of Mr. B. Pickman Mann, but was in such shape when he left the office as to require almost entire rewriting. This has been mainly done by Mr. E. A. Schwarz, though other members of the Divisional force have assisted.

C. V. R.

PUBLISHED SYNOPSES, CATALOGUES, AND LISTS OF NORTH AMERICAN INSECTS.

COMPREHENSIVE WORKS MOST USEFUL FOR THE STUDY OF NORTH AMERICAN INSECTS.

H. C. C. BURMEISTER.—Handbuch der Entomologie. Berlin, 1832-'55. 5 vols. Vol. I. Allgemeine Entomologie.

The first volume treats of general entomology; Vol. II, part 1, of the Hemiptera; part 2, of Orthoptera; the remaining volumes of Coleoptera.

The first volume has been translated by W. E. Shuckard, under the title: Manual of Entomology. 1 vol. London, 1836.

J. O. WESTWOOD.—An introduction to the modern classification of insects, founded on the natural habits and corresponding organization of the different families. 2 vols. London, 1839-'40.

THOMAS SAY.—Complete writings on the Entomology of North America edited by John L. Le Conte. New York, 1859.

H. A. HAGEN.—Bibliotheca Entomologica. Die Litteratur über das ganze Gebiet der Entomologie bis zum Jahre 1862. Leipzig, 1862.

A. S. PACKARD.—Guide to the study of insects. Henry Holt & Co., Philadelphia and New York. Many editions. (First edition, Salem, 1869.)

THE STANDARD NATURAL HISTORY. Edited by John Sterling Kingsley. Boston, S. E. Cassino & Co., 1884-'85.

Volume II contains the insects, which are treated by the following authors: *Hymenoptera*, J. H. Comstock and L. O. Howard; *Coleoptera*, Geo. Dimmock; *Lepidoptera*, Hy Edwards and C. H. Fernald; *Diptera*, S. W. Williston; *Orthoptera*, C. V. Riley; *Hemiptera*, P. R. Uhler; *Neuroptera*, A. S. Packard; *Arachnida*, J. H. Emerton.

HYMENOPTERA.

I.—CATALOGUES.

E. T. CRESSON.—Catalogue of the described species of North American Hymenoptera. <Proc. Entomol. Soc. of Philadelphia, Vol. I, 1861-'63.

E. T. CRESSON.—Catalogue of Species and Bibliography. Part 2 of Synopsis of the Hymenoptera of America, north of Mexico. <Transactions of the Am. Entomol. Soc., Supplementary volume, 1887. Phila., 1887.

II.—GENERAL WORKS ON CLASSIFICATION.

E. T. CRESSON.—Synopsis of the families and genera of the Hymenoptera, north of Mexico, together with a catalogue of the described species and bibliography. <Transactions Am. Entomol. Society, Supplementary volume, Part I, 1887.

The second part contains the Catalogue of Species and Bibliography.

III.—MONOGRAPHS AND SYNOPSES.

TENTHREDINIDÆ AND URO CERIDÆ.

EDWARD NORTON.—Catalogue of the described Tenthredinidæ and Uroceridæ of North America. <Trans. Amer. Ent. Soc., Vol. I, 1867, pp. 31-84 and 193-280; Vol. II, 1868-'69, pp. 211-242 and 321-367.

Gives synoptic tables of genera and species of both families; the Uroceridæ are treated in Vol. II, pp. 349-367.

E. T. CRESSON.—Catalogue of the Tenthredinidæ and Uroceridæ of North America. <Trans. Amer. Ent. Soc., Vol. VIII, 1880, pp. 53-68.

A synonymical reference list of the species; the Uroceridæ are treated on pp. 66, 67.

PETER CAMERON.—Monograph of the British Phytophagous Hymenoptera. 2 vols. London, 1882-'85.

Contains an arrangement of the subfamilies and genera of Tenthredinidæ, which has been reproduced by Cresson in his general work of classification.

CYNIPIDÆ.

R. OSTEN SACKEN.—On the Cynipidæ of the North American oaks and their galls. <Proc. Entom. Soc. Philadelphia, Vol. I, 1861-'63, pp. 47-72; additions and corrections, *l. c.*, pp. 241-259.

R. OSTEN SACKEN.—Contributions to the Natural History of the Cynipidæ of the United States. <Proc. Entom. Soc. Phil., Vol. II, 1863-'64, pp. 33-49; Vol. IV, 1865, pp. 331-380; Trans. Amer. Ent. Soc., Vol. III, 1870-'71, pp. 54-64.

Continuation of the foregoing paper, both containing valuable contributions to the classification of genera and species.

B. D. WALSH.—On Dimorphism in the Hymenopterous genus *Cynips*: with an Appendix, containing hints for a new classification of Cynipidæ, including descriptions of several new species inhabiting the Oak galls of Illinois. <Proc. Entom. Soc. Phil., Vol. II, 1833-'64, pp. 443-500.

GUSTAV MAYR.—Die Genera der gallenbewohnenden Cynipiden. <20ter Jahresbericht der Communal-Oberrealschule im I. Bezirk. Wien, 1881.

W. H. ASHMEAD.—A bibliographical and synonymical catalogue of the North American Cynipidæ, with description of new species. <Trans. Amer. Entom. Soc., Vol. XII, 1885, pp. 291-304.

W. H. ASHMEAD.—Synopsis of the North American subfamilies and genera of Cynipidæ. <Trans. Amer. Ent. Soc., Vol. XIII, 1886, pp. 59-64.

W. H. ASHMEAD.—On the Cynipidous Galls of Florida, with descriptions of new species and Synopses of the described species of North America. <Trans. Am. Entom. Soc., Vol. XIV, 1887, No. 2, pp. 125-158.

ICHNEUMONIDÆ.

EDWARD NORTON.—Catalogue of our species of *Ophion*, *Anomalon*, *Paniscus*, and *Campoplex*. <Proc. Entom. Soc. Phil., Vol. I, 1863, pp. 357-368.

Synoptic arrangement of the North American genera and species of the subfamily Ophioninæ.

E. T. CRESSON.—Descriptions of North American Hymenoptera in the collection of the Entomological Society of Philadelphia. <Proc. Entom. Soc. of Phil., Vol. III, 1864, pp. 131-196.

Consists chiefly of a synopsis of the North American species of the genus *Ichneumon*.

E. T. CRESSON.—A list of the Ichneumonidæ of North America, with descriptions of new species. <Trans. Amer. Entom. Soc., Vol. I, 1867, pp. 289-312; Vol. II, 1868-'69, pp. 89-114.

E. T. CRESSON.—Descriptions of new species belonging to the subfamily Pimplariæ found in America, north of Mexico. <Trans. Amer. Entom. Soc., Vol. III, 1870-'71, pp. 143-172.

Tabulates the genera *Pimpla*, *Polysphincta*, *Glypta*, *Arenetra*, *Lampronota*, *Xylonomus*, *Odontomerus*, with a list of all species.

B. D. WALSH.—Descriptions of North American Hymenoptera [with notes by E. T. Cresson]. <Trans. St. Louis Acad. Sci., Vol. III, 1873, pp. 65-166.

E. T. CRESSON.—Notes on the species belonging to the subfamily Ichneumonides found in America, north of Mexico. <Trans. Amer. Entom. Soc., Vol. VI, 1877, pp. 129-212.

A synopsis of the genera and species of the subfamily Ichneumoninae.

BRACONIDÆ.

E. T. CRESSON.—List of the North American species of the genus *Alciodes*, Wesmæl. <Trans. Amer. Entom. Soc., Vol. II, 1868-'69, pp. 377-382.

C. V. RILEY.—On North American Microgasters, with descriptions of new species. <Trans. St. Louis Ac. Sc., Vol. IV, No. 2, 1881.

T. A. MARSHALL.—Monograph of the British Braconidæ. Part I. <Trans. Entom. Soc. London, 1885, pp. 1-280, Pl. I-IV.

Marshall's classification is that reproduced by Cresson in his Synopsis.

CHALCIDIDÆ.

A. FOERSTER.—Synoptische Uebersicht der Familien und Gattungen in den beiden Gruppen der Chalcididæ Spin. und Proctotrupii Latr. <Jahresber. d. höheren Bürgerschule in Aachen, 1856.

E. T. CRESSON.—Synopsis of the North American species belonging to the genera *Leucospis*, *Smicra*, and *Chalcis*. <Trans. Amer. Entom. Soc., Vol. IV, 1872-'73, pp. 29-60.

L. O. HOWARD.—Descriptions of North American Chalcididæ from the collections of the U. S. Department of Agriculture and of Dr. C. V. Riley, with biological notes [first paper], together with a list of the described North American species of the family. <U. S. Department of Agriculture, Bureau of Entomology. Bulletin No. 5. Washington, 1885.

L. O. HOWARD.—A generic synopsis of the Hymenopterous family Chalcididæ. <Entomol. Amer., Vol. I, 1885-'86, pp. 197-199 and 215-219; Vol. II, pp. 33-38.

PROCTOTRUPIDÆ.

L. O. HOWARD.—A generic synopsis of the Hymenopterous family Proctotrupidæ. <Trans. Amer. Entom. Soc., Vol. XIII, 1886, pp. 169-178.

CHRYSIDIDÆ.

EDWARD NORTON.—On the Chrysidæ of North America. <Trans. Amer. Entom. Soc., Vol. VII, 1878-'79, pp. 233-242.

Gives tables of genera and species.

S. FRANK AARON.—The North American Chrysididæ. <Trans. Amer. Entom. Soc., Vol. XII, 1835, pp. 209-248, Pl. VI-X.

FORMICIDÆ (including allied families).

- G. L. MAYR.—Die Formiciden der Vereinigten Staaten von Nordamerika.
<Verh. zool.-bot. Ges. in Wien, 1886.

MUTILLIDÆ.

- CH. A. BLAKE.—Synopsis of the Mutillidæ of North America. <Trans. Amer. Entom. Soc., Vol. III, 1870-'71, pp. 217-265; Additions and Corrections, Vol. IV, 1872-'73, pp. 71-76.

- CH. A. BLAKE.—Catalogue of the Mutillidæ of North America, with descriptions of new species. <Trans. Amer. Entom. Soc., Vol. VII, 1878-'79, pp. 243-254.

- CH. A. BLAKE.—Monograph of the Mutillidæ of North America.
<Trans. Amer. Entom. Soc., Vol. XIII, 1886, pp. 179-286.

This monograph supersedes the synopsis by the same author.

SCOLIIDÆ.

- H. DE SAUSSURE & J. SICHEL.—Catalogus specierum generis Scolia,
Genève, 1864.

SAPYGIDÆ.

- E. T. CRESSON.—[Synoptic table of the North American species of Sapyga.] <Trans. Amer. Ent. Soc., Vol. VIII, 1880, pp. xx-xxi.

POMPILIDÆ.

- E. T. CRESSON.—Notes on the Pompilidæ of North America, with descriptions of new species. <Trans. Amer. Ent. Soc., Vol. I, 1867, pp. 85-150.

SPHECIDÆ.

- W. H. PATTON.—Some characters useful in the study of Sphecidæ.
<Proc. Boston Soc. Nat. Hist., Vol. XX, 1880, pp. 378-385.
Critical notes on genera and species.

LARRIDÆ.

- A. S. PACKARD, JR.—Revision of the Fossorial Hymenoptera of North America. I. Crabronidæ and Nyssonidæ. <Proc. Entom. Soc. Phil., Vol. VI, 1866, pp. 39-114 and 353-444.

This work includes revisions of the following families: Larridæ, Bembecidæ, Philanthidæ, Mimesidæ, Mellinidæ, Pemphredonidæ, and Crabronidæ.

- W. H. PATTON.—List of North American Larridæ. <Proc. Boston Soc. Nat. Hist., Vol. XX, 1880, pp. 385-397.

Table of genera; list of and notes on species.

BEMBECIDÆ.

- A. S. PACKARD, JR.—[See work cited under Larridæ.]

- W. H. PATTON.—The American Bembecidæ: Tribe Stizini. <Bull. U. S. Geolog. and Geogr. Survey, Vol. V, No. 3, 1879, pp. 341-347.

NYSSONIDÆ.

A. S. PACKARD, Jr.—[See work cited under Larridæ.]

E. T. CRESSON.—Descriptions of the species belonging to the genus Nysson, inhabiting North America. <Trans. Amer. Entom. Soc., Vol. IX, 1881-'82, pp. 273-284.

PHILANTHIDÆ.

E. T. CRESSON.—Monograph of the Philanthidæ of North America. <Proc. Entom. Soc. Phil., Vol. V, 1865, pp. 85-132.

A. S. PACKARD, Jr.—[See work cited under Larridæ.]

W. H. PATTON.—Notes on the Philanthinæ. <Proc. Boston Soc. Nat. Hist., Vol. XX, 1880, pp. 397-405.

E. T. CRESSON.—[Table of the North American species of the genus Eucerceris.] <Trans. Amer. Entom. Soc., Vol. X, 1882-'83, pp. v-viii.

MIMESIDÆ.

A. S. PACKARD, Jr.—[See work cited under Larridæ.]

MELLINIDÆ.

A. S. PACKARD, Jr.—[See work cited under Larridæ.]

PEMPHREDONIDÆ.

A. S. PACKARD, Jr.—[See work cited under Larridæ.]

CRABRONIDÆ.

A. S. PACKARD, Jr.—[See work cited under Larridæ.]

MASARIDÆ.

HENRI DE SAUSSURE.—Synopsis of American Wasps. Solitary Wasps. <Smithsonian Miscellaneous Collections, 254, Washington, 1875.
This work monographs the American Masaridæ and Eumenidæ

EUMENIDÆ.

HENRI DE SAUSSURE.—[Work just cited.]

VESPIDÆ.

HENRI DE SAUSSURE.—Études sur la famille des Vespides. Monographie des guêpes sociales ou de la tribu des Vespiciens. Paris, 1853.

HENRI DE SAUSSURE.—Bemerkungen über die Gattung Vespa, besonders über die amerikanischen Arten. <Stettiner Entom. Zeit., Vol. XVIII, 1857, pp. 114-117.

HENRI DE SAUSSURE.—Note sur les Polistes américains. <Ann. Soc. Entom. France, 1857, pp. 309-314.

ANTHOPHILA (*Andrenidæ* and *Apidæ*).

- E. T. CRESSON.—A list of the North American species of the genus *Anthophora*, with descriptions of new species. <Trans. Amer. Entomol. Soc., Vol. II, 1868-'69, pp. 289-293.
- E. T. CRESSON.—Catalogue of North American *Apidæ*. <Trans. Amer. Entom. Soc., Vol. VII, 1878-'79, pp. 215-232.
A synonymical reference list of the species.
- W. H. PATTON.—Generic arrangement of the Bees allied to *Melissodes* and *Anthophora*. <Bulletin U. S. Geol. and Geogr. Survey, Vol. V, No. 3, 1879, pp. 471-479.

COLEOPTERA.

I.—CATALOGUES AND CHECK-LISTS.

F. E. MELSHEIMER.—Catalogue of the described Coleoptera of the United States. Revised by S. S. Haldeman and J. L. Le Conte. Washington, Smithsonian Institution, 1853.

Now antiquated, but still the only reference catalogue of North American Coleoptera.

JOHN L. LE CONTE.—List of the Coleoptera of North America. Prepared for the Smithsonian Institution. Part I. Washington, Smithsonian Institution, 1863-'66.

A synonymical check-list; incomplete, the second part having never been published.

G. R. CROTCH.—Check-list of the Coleoptera of America, north of Mexico. Salem, Mass., Naturalists' Agency, 1873.

GEMMINGER AND HAROLD.—Catalogus Coleopterorum hucusque descriptorum synonymicus et systematicus. 12 vols. Munich, 1868-'76.

A synonymical reference catalogue of the Coleoptera of the whole world.

E. P. AUSTIN.—Supplement to the Check-list of the Coleoptera of America, north of Mexico. Boston, S. E. Cassino, 1880.

SAMUEL HENSHAW.—List of the Coleoptera of America, north of Mexico. Philadelphia, American Entomological Society, 1885.

This supersedes all previous lists.

SAMUEL HENSHAW.—First Supplement to the List of Coleoptera of America, north of Mexico. <Entomologica Americana, Vol. II, 1887, pp. 213-220.

Also issued as separate pamphlet by the Brooklyn Entomological Society.

II.—GENERAL WORKS ON CLASSIFICATION.

J. L. LE CONTE.—Classification of the Coleoptera of North America. Washington, Smithsonian Institution. Part I, 1861; Part II, 1873.

Only completed as far as the Cerambycidae; the rest has never been published.

WILLIAM LE BARON.—Outlines of Entomology, published in connection with the author's Annual Reports upon injurious insects. Part first. Including the Order of Coleoptera. Fourth Annual Report on the Noxious and Beneficial Insects of the State of Illinois. Sep. Edit. Springfield, 1874.

J. T. LACORDAIRE.—Histoire naturelle des Insectes. Genera des Coléoptères, ou exposé méthodique et critique de tous les genres proposés jusqu'ici dans cet ordre d'insectes. [Completed by J. Chapuis.] Paris, France, 1854-'76. 12 vols. and 1 vol. plates.

JOHN L. LE CONTE AND GEORGE H. HORN.—Classification of the Coleoptera of North America. Prepared for the Smithsonian Institution. Washington, Smithsonian Institution, 1883.

This is the most recent and the only complete classification of North American Coleoptera.

JOHN L. LE CONTE.—New Species of North American Coleoptera. Smithsonian Miscell. Coll., Nos. 167 and 264 (2 parts).

Contains, besides descriptions of numerous isolated species, synoptic tables of many genera.

III.—MONOGRAPHS AND SYNOPSES.

SAMUEL HENSHAW.—References for specific identification. <Appendix II of Le Conte and Horn's "Classification," 1883, pp. 535-552.

A "list of bibliographical references to memoirs, in which more or less complete synopses of the families, genera, and species of the Coleoptera of the United States have been published."

Since the following list includes only synopses on families, subfamilies, or tribes, Mr. Henshaw's paper must be consulted in regard to single genera.

CICINDELIDÆ.

F. G. SCHAUPP.—Synoptic tables of Coleoptera, Cicindelidæ. <Bull. Brooklyn Entomological Society, Vol. VI, November, 1883, and subsequent numbers. Also issued as separate pamphlet by the Brookl. Ent. Soc.

CARABIDÆ.

J. L. LE CONTE.—Notes on the classification of the Carabidæ of the United States. <Trans. Amer. Philos. Soc., Ser. 2, 1853, Vol. X, pp. 363-403.

GEORGE H. HORN.—On the genera of Carabidæ, with special reference to the fauna of Boreal America. <Trans. Amer. Entom. Soc., Vol. IX, 1882, pp. 91-196, Pl. III-X.

Of most of our genera of this extensive family we have monographs or synopses by Drs. Le Conte, Horn, or by Mr. Crotch, and the tables for the determination of the species are reproduced and augmented by some original tables in the Bulletin of the Brookl. Ent. Soc., from Vol. I to Vol. VI. Since that time only one important paper has been published, viz:

GEORGE H. HORN.—Synopsis of the species of the tribe Lebiini. <Trans. Amer. Ent. Soc., Vol. X, 1883, pp. 126-163.

HALIPLIDÆ.

G. R. CROTCH.—Revision of the Dytiscidæ of the United States.
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CHAS. W. LENG.—Synopsis of Coleoptera [Cerambycidæ]. <Bull. Brookl. Ent. Soc., Vol. VII, 1884, No. 1, p. 7, and in subsequent numbers; continued in *Entomologica Americana*, Vols. I–III, and not yet completed.

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The few species of the single genus constituting this family have been tabulated by Dr. Horn in Trans. Amer. Ent. Soc., Vol. II, 1868, pp. 132, 133.

LAGRIIDÆ.

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MONOMMIDÆ.

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A monograph of the family of the whole world. The few (four) species hitherto found in North America are tabulated by Dr. Horn in Trans. Amer. Ent. Soc., Vol. IV, 1872, p. 150.

MELANDRYIDÆ.

No complete synopsis has hitherto been published, and excepting a table of Hallomenus, by Dr. Le Conte (Proc. Amer. Philos. Soc., Vol. XVII, 1878, p. 619), we can only record the following paper.

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Tabulates Mycterus and Lacconotus.

GEO. H. HORN.—Miscellaneous Coleopterous studies. <Trans. Amer. Ent. Soc., Vol. XV., 1888.

Contains on pp. 32-44 a revised table of the tribes of Melandryidæ and tables of the genera Eustrophus, Holostrophus, Orchesia, and Hypulus.

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Excepting the table of Cononotus, by Dr. Horn (Trans. Am. Ent. Soc., Vol. II, 1868, p. 136), and a table of Pytho, by the same author (l. c. Vol. XV, 1888, p. 45), we have no synoptic papers on this family.

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JOHN L. LE CONTE.—Synopsis of the CedeMERIDÆ of the United States. <Proc. Ac. Nat. Sc. Phil., Vol. VII, 1854, pp. 20-22.

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The few species composing this family are tabulated by Dr. Le Conte in Mr. E. P. Austin's Catalogue of the Coleoptera of Mount Washington, N. H. <Proc. Boston Soc. Nat. Hist., Vol. XVI, 1874, pp. 265-276.

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The tribes Pedilini, Xylophilini, and Macratrini, formerly attached to the Pyrochroidæ, are here treated.

GEORGE H. HORN.—Synopsis of the species of *Corphyra* Say. of the United States. <Trans. Amer. Ent. Soc., Vol. III, 1871, pp. 278-283.

For subsequent tables by Dr. Horn of the same genus see Trans. Amer. Ent. Soc., Vol. V, 1874, p. 40, and, *l. c.*, Vol. X, 1883, pp. 305-310.

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GEORGE H. HORN.—Miscellaneous Coleopterous studies. <Trans. Amer. Ent. Soc., Vol. XV, 1888.

Contains on p. 47 a table of Dendroides.

MELOIDÆ.

JOHN L. LE CONTE.—Synopsis of the Meloides of the United States. <Proc. Ac. Nat. Sc. Phil., Vol. VI, 1853, pp. 328-350.

GEORGE H. HORN.—Revision of the species of several genera of Meloidæ of the United States. <Proc. Am. Philos. Soc., Vol. XIII, 1873, pp. 88-117.

Gives tables of *Macrobasis*, p. 88; *Epicauta*, p. 95; *Cantharis*, p. 103; *Pomphopœa*, p. 115.

RHYNCHOPHORA.

C. J. SCHENKERR.—Genera et species Curculionidum cum synonymia hujus familiæ... 8 vols., Paris, 1833-'34.

An additional volume, *Mantissa secunda familiæ Curculionidum*, appeared in 1847.

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C. ZIMMERMAN.—Synopsis of the Scolytidæ of America, north of Mexico. With Notes and an Appendix by J. L. Le Conte. <Trans. Amer. Ent. Soc., Vol. II, 1868, pp. 141-178.

GEORGE H. HORN.—The Brentidæ of the United States. <Trans. Amer. Ent. Soc., Vol. IV, 1872, pp. 127-129.

GEORGE H. HORN.—Contributions to a knowledge of the Cynallioniidæ of the United States. <Proc. Amer. Philos. Soc., Vol. XIII, 1873, pp. 407-469.

A revision of the *Cynallionia* and synopsis of *Othinosphindus*, p. 448; *Margalis*, p. 452; *Balaninus*, p. 457; *Orchestes*, p. 461; *Hypocnemis*, p. 464; *Chalcodermus*, p. 465; *Analeis*, p. 467.

JOHN B. SMITH.—Synopsis of the Apionine of North America. <Trans. Amer. Ent. Soc., Vol. XI, 1874, pp. 41-68, 3 plates.

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A monograph of the North American Rhynchophora.

FREDERICK BLANCHARD.—Table of *Balaninus* Germ. <Bull. Brook. Ent. Soc., Vol. VII, 1884, pp. 106-108.

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I.—CATALOGUES AND LISTS.

J. G. MORRIS.—Catalogue of the described Lepidoptera of North America. Washington, Smithsonian Institution, 1860.

This is the first catalogue of the North American Lepidoptera, but now greatly antiquated and superseded.

J. W. WEIDEMEYER.—Catalogue of North American Butterflies. <Proc. Entom. Soc. Phil., Vol. II, 1863-'66, pp. 143-154 and 513-542.
Superseded by subsequent papers.

A. R. GROTE AND C. T. ROBINSON.—A synonymical catalogue of North American Sphingidae, with notes and descriptions. <Proc. Entom. Soc. Phil., Vol. V, 1865, pp. 149-193, 3 plates.

Gives full and complete synonymy, with descriptions of several new genera and species.

A. R. GROTE AND C. T. ROBINSON.—List of the Lepidoptera of North America. Philadelphia, Amer. Ent. Soc., 1868.

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A. R. GROTE.—List of the Noctuidae of North America. <Bull. Buffalo Soc. Nat. Hist., Vol. II, 1874, pp. 1-77.

The only synonymical and bibliographical catalogue of the North American Noctuidae.

S. H. SCUDDER.—Synonymic list of the Butterflies of North America, north of Mexico. Part I. Nymphales. <Bull. Buff. Soc. Nat. Hist., Vol. II, 1875, pp. 233-269; Part II. Rurales. <*L. c.*, Vol. III, 1876, pp. 98-129.

Contains a very complete synonymy, but its classification has not been adopted by subsequent writers.

W. F. KIRBY.—A synonymic catalogue of diurnal Lepidoptera. London, 1871; Supplement, London, 1877.

A complete synonymical list of the diurnals of the world.

B. GERHARD.—Systematisches Verzeichniss der Macrolepidopteren von Nord-Amerika. Leipzig, 1878.

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H. STRECKER.—Butterflies and Moths of North America. Diurnes. Reading, Pa., 1878.

A very complete synonymical and annotated catalogue, with glossary of terms and an introductory chapter giving directions for collecting, preserving, and shipping butterflies.

V. T. CHAMBERS.—Index to the described Tineina of the United States and Canada. <Bull. U. S. Geol. Survey Terr., Vol. IV, 1878, pp. 125-167.

An annotated catalogue, with descriptions of many new species.

BROOKLYN ENTOMOLOGICAL SOCIETY.—Check-list of the Macrolepidoptera of America, north of Mexico. Brooklyn, N. Y., 1882.

A. R. GROTE.—New Check List of North American Moths. New York, Author, 1882.

A list of all heterocerous Macrolepidoptera; also the Pyralidæ and Tortricidæ. Supersedes several previous lists by the same author.

C. H. FERNALD.—A synonymical catalogue of the described Tortricidæ of North America, north of Mexico. <Trans. Amer. Ent. Soc., Vol. X, 1882, pp. 1-64; also separate.

W. H. EDWARDS.—Revised catalogue of the Diurnal Lepidoptera of America north of Mexico. <Trans. Amer. Entom. Soc., Vol. XI, 1884, pp. 245-338.

This is the most recent reference and synonymic catalogue, superseding a similar catalogue by the same author published in 1877.

W. H. EDWARDS.—List of species of the Diurnal Lepidoptera of America north of Mexico. Boston, Houghton, Mifflin & Co., 1884, 4to.

A mere list of the species, following in all respects the catalogue just cited, and printed to accompany Vol. II of the "Butterflies of North America."

II.—GENERAL WORKS ON CLASSIFICATION.

G. A. W. HERRICH-SCHAEFFER.—Sammlung neuer oder wenig bekannter aussereuropäischer Schmetterlinge. Vol. I. Regensburg, 1850-58; Vol. II, Pt. 1, 1869.

Contains a classification of the Lepidoptera, which forms the basis of our present arrangement.

JOHN G. MORRIS.—Synopsis of the described Lepidoptera of North America. Part I. Diurnal and Crepuscular Lepidoptera. Washington, Smithsonian Institution, 1862.

Compiled descriptions of the North American Lepidoptera, from the Rhopalocera to the Bombycidæ.

H. STRECKER.—Lepidoptera, Rhopaloceres et Heteroceres, indigenous and exotic; with descriptions and colored illustrations. Reading, Pa., 1872-77.

Fifteen parts of this work have been published containing figures and descriptions of many North American species.

JOHN B. SMITH.—An introduction to a classification of the North American Lepidoptera. <Bull. Brookl. Ent. Soc., Vol. VII, 1884, pp. 70-74 and 81-83.

A synopsis of the families of Lepidoptera, based on Herrich-Schaeffer's classification.

III.—MONOGRAPHS AND SYNOPSES.

Rhopalocera.

J. A. BOISDUVAL.—Histoire naturelle des Insectes. Spécies général des Lépidoptères. Suites à Buffon. Paris, 1836.

Contains full descriptions of the known species, but extends only from Papilio to the end of Terias.

E. DOUBLEDAY AND W. C. HEWITSON.—The genera of diurnal Lepidoptera, comprising their generic characters, a notice of their transformations, and a catalogue of the species of each genus; illustrated, with 86 colored plates from drawings by W. C. Hewitson. 2 vols., London, 1846-52.

This work was completed by Westwood after the death of Doubleday.

S. H. SCUDDER.—Butterflies: Their structures, changes, and life-histories, with special reference to American forms. Being an application of the "Doctrine of descent" to the study of Butterflies, with an appendix of practical instructions. New York, Henry Holt & Co., 1881.

CARL PLOETZ.—Die Hesperinen-Gattung *Hesperia* Aut. und ihre Arten. <Stettin. entom. Zeit., 1882, pp. 314-344, continued in subsequent volumes.

JOHN B. SMITH.—Synopsis of the genera of the North American Rhopalocera. <Bull. Brookl. Ent. Soc., Vol. VI, 1883, pp. 37-45.

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C. H. FERNALD.—The Butterflies of Maine. Designed for the use of the students in the Maine State College, and the farmers of the State. Orono, Me., 1884.

G. H. FRENCH.—The Butterflies of the Eastern United States. For the use of classes in Zoology and private students. Philadelphia, Lippincott & Co., 1886.

Gives synopses of the genera and species, and descriptions of the species.

BROOKLYN ENTOMOLOGICAL SOCIETY.—Synopsis of Butterflies. <Bull. Brooklyn Entom. Soc., Vol. I and subsequent volumes; continued in *Entomologica Americana*, Vol. I.

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SAMUEL H. SCUDDER.—Comparative tables for the families of Butterflies. <Canad. Entom. Vol. XIX, 1887, No. 11, pp. 201-206.

W. H. EDWARDS.—Butterflies of North America. Boston, Houghton, Mifflin & Co.

Two volumes are completed and the third is in course of publication.

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- T. W. HARRIS.—Descriptive Catalogue of the North American insects belonging to the Linnaean genus *Sphinx*, in the cabinet of Thaddeus William Harris, M. D., librarian of Harvard University. <Amer. Journ. Sc. and Arts, Vol. XXXVI, 1839, pp. 282-320.

Includes not only the Sphingidæ as at present limited, but also the Zygænidæ of Grote's new list.

- B. CLEMENS.—Synopsis of the North American Sphingides. <Journ. Ac. Nat. Sc. Phil., Vol. IV, Pt. 2, 1859, pp. 97-190.

A monograph of the family as at present limited.

- J. A. BOISDUVAL.—Sphingides, Sesiides, Castniides. Paris, Roret 1874.

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- A. G. BUTLER.—Revision of the Heterocerous Lepidoptera of the family Sphingidæ. <Trans. Zool. Soc. London, Vol. IX, 1877, pp. 511-644, Pl. XC-XCIV.

A descriptive catalogue.

- JOHN B. SMITH.—An introduction to a classification of the North American Lepidoptera. Sphingidæ. <Entom. Amer., Vol. I, 1885, pp. 81-87.

Contains a synopsis of the genera, with brief remarks on each.

- C. H. FERNALD.—The Sphingidæ of New England. Orono, Me., 1886.

Gives the life-history, so far as known, of all species recorded from New England.

- JOHN B. SMITH.—A monograph of the Sphingidæ of North America, north of Mexico. <Trans. Amer. Ent. Soc., Vol. XV, 1888, Part II, 12 plates.

[This is not published but is included here because now in the printer's hands.—C. V. R.]

SESIIDÆ.

See papers by Harris and Boisduval above cited, who treat the Sesiidæ as a part of the Sphingidæ, both works being antiquated so far as they relate to the Sesiidæ.

- JOHN B. SMITH.—An introduction to a classification of the North American Lepidoptera. <Entom. Amer., Vol. IX., 1888, pp. 9-13.

THYRIDÆ.

This family has also been treated by Harris and Boisduval as a part of the Sphingidæ.

ZYGÆNIDÆ.

- A. S. PACKARD, Jr.—Notes on the family Zygænidæ. <Proc. Essex Institute, Vol. IV, 1864, pp. 7-47, Pl. I, II.

Description of a number of new genera and species, with notes on others.

- A. R. GROTE.—Catalogue of the Zygaenidæ of North America. <Bull. Buffalo Soc. Nat. Sc., Vol. I, 1873, pp. 29-36.
- R. H. STRETCH.—Illustrations of the Zygaenidæ and Bombycidæ of North America. San Francisco, Cal., Author, 1874.
- JOHN B. SMITH.—Notes on the systematic position of some North American Lepidoptera. <Trans. Amer. Entom. Soc., Vol. XII, 1885, pp. 77-84.
- Discusses the genera classed as Zygaenidæ in Grote's list, and separates them into carefully defined groups.

BOMBYCIDÆ.

- A. S. PACKARD, JR.—Synopsis of the Bombycidæ of the United States. <Proc. Entom. Soc. Phil., Vol. III, 1864, pp. 97-130 and 331-396.
- A. R. GROTE.—On the North American Platypteryginæ. <Trans. Amer. Ent. Soc., Vol. II, 1868, pp. 65-67.
- A. R. GROTE.—List of the North American Platypteryices, Attaci, Hemileucini, Ceratocampadæ, Lachneides, Teredines, and Hepiali, with notes. <Proc. Amer. Philos. Soc., Vol. XIV, 1874, pp. 256-264.
- R. H. STRETCH.—Illustrations of the Zygaenidæ and Bombycidæ of North America. San Francisco, Cal., Author, 1874.
- The Lithosiidæ and Arctiidæ are principally treated.
- A. G. BUTLER.—On the Lepidoptera of the family Lithosiidæ, in the collection of the British Museum. <Trans. Entom. Soc. London, 1877, pp. 325-377, Pl. VIII.
- A. R. GROTE.—Table of species of Euchætetes. <Canad. Entom., Vol. XIV, 1882, pp. 196, 197.
- J. S. BAILEY.—Some of the North American Cossidæ, with facts in the life history of *Cossus centerensis* Lintner. <Bull. No. 3, 1883, U. S. Department of Agricult., Divis. of Entomol., pp. 49-55, Pl. I, II.
- H. H. LYMAN.—The North American Callimorphas. <Canad. Ent. Vol. XIX, 1887, pp. 181-191, plate.
- JOHN B. SMITH.—The North American species of Callimorpha, Latr. <Proc. U. S. Nat. Mus., 1887, pp. 342-353, Pl. XIII, XIV.

NOCTUIDÆ.

- A. GUENÉE.—Noctuelites. Spécies général des Lépidoptères. Suites à Buffon. Paris, Roret, 1852, Vols. 5-7.
- Vol. VIII of the same work treats the Deltoides et Pyralites, the former group now being attached to the Noctuidæ.
- A. R. GROTE.—A Revision of the species of Cymatophorina found in the United States and British America, with descriptions of new species. <Proc. Entom. Soc. Phil., Vol. II, 1863, pp. 54-59.

- A. R. GROTE.—The species of *Erotyla*, *Spragueia*, *Fruva*, *Xanthoptera*, *Exyra*, and *Prothymia*. <Canad. Ent., Vol. XI, 1879, pp. 231–238.
- A. R. GROTE.—On the described North American species of *Thalpochares*. <Canad. Entom., Vol. XII, 1880, pp. 57–59.
- A. R. GROTE.—List of North American *Bombyciæ* of Hübner. <Canad. Entom., Vol. XIII, 1881, pp. 151–153.
- A. R. GROTE.—Preliminary list of the North American species of *Agrotis*, with descriptions. <Bull. U. S. Geol. Survey, Vol. VI, 1881, pp. 149–164.
- A. R. GROTE.—North American Moths, with a preliminary catalogue of the species of *Hadena* and *Polia*. <Bull. U. S. Geol. and Geogr. Survey, Vol. VI, 1881, pp. 257–277.
- A. R. GROTE.—The North American species of *Mamestra*. <Canad. Entom., Vol. XIII, 1881, pp. 126–130.
- A. R. GROTE.—New Noctuids, with a list of the species of *Oncocnemis*. <Papilio, Vol. I, 1881, pp. 33–35.
- A. R. GROTE.—New Noctuidæ, with list of species of *Perigrapha*. <Can. Ent., Vol. XIII, 1881, pp. 131–134.
- A. R. GROTE.—The North American species of *Eustrotia*. <Papilio, Vol. I, 1881, pp. 10–11.
- JOHN B. SMITH.—A synopsis of the North American genera of the Noctuidæ. <Bull. Brooklyn Entom. Soc., Vol. IV, 1882, pp. 48–52, and Vol. V, from May till November, 1882.
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- JOHN B. SMITH.—Remarks on the generic characters of the Noctuidæ. <Canad. Ent., Vol. XIV, 1882, pp. 65–72.
- GEO. H. FRENCH.—Synopsis of the Noctuidæ of Illinois. Greenville, Ills., 1882. <Curator's Report in the eighth Ann. Rep. of the Principal to the Board of Trustees of the South Ill. Normal University.
- A. R. GROTE.—Notes on the genus *Tripudia*, and on the species of *Spragueia*. <Canad. Ent., Vol. XIV, 1882, pp. 32–33.
- A. R. GROTE.—List of the species of *Tripudia* and *Gyros*. <Canad. Entom., Vol. XIV, 1882, pp. 195–196.
- A. R. GROTE.—Introduction to a study of the North American Noctuidæ. <Proc. Amer. Philos. Soc., Vol. XXI, 1883, pp. 134–176.
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A. R. GROTE.—List of *Apatelæ* belonging to the groups *Aeronieta* and *Triana*. <Papilio, Vol. III, 1883, pp. 67–70.

A. R. GROTE.—Conclusion of List of American *Apatelas*. <Papilio, Vol. III, 1883, pp. 111–117.

A. R. GROTE.—On the North American *Calpinæ* to *Heliothinae*. <Canad. Ent., Vol. XV, 1883, pp. 72–77 and 102–110.

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A. R. GROTE.—Remarks upon the North American *Heliothinae* and their recent literature. <Trans. Amer. Ent. Soc., Vol. X, 1883, pp. 257–268.

G. D. HULST.—The genus *Catocala*. <Bull. Brookl. Ent. Soc., Vol. VII, 1884, pp. 13–56, Pl. I.

A complete monograph of the genus.

GEOMETRIDÆ.

A. S. PACKARD, Jr.—A monograph of the Geometrid moths or *Phalanidæ* of the United States. <U. S. Geological Survey of the Terr. Department of the Interior. F. V. Hayden, U. S. Geologist in charge. Report, Vol. X, Washington, D. C., 1876, pp. 607, 13 plates.

This supersedes all prior works and gives a complete index to the prior literature as well as a description of every species.

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A. R. GROTE.—Preliminary studies on the North American *Pyralidæ*. <Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, 1878, pp. 669–705.

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TORTRICIDÆ.

COLEMAN T. ROBINSON.—Notes on American *Tortricidæ*. <Trans. Amer. Ent. Soc., Vol. II, 1869, pp. 261–288, Pls. I and IV–VIII.

THOMAS, LORD WALSHINGHAM.—North American *Tortricidæ*. British Museum. Illustrations of typical specimens of *Lepidoptera heterocera* in the collection of the British Museum. 1 vol., folio, 1879, pp. 12+84, Pl. XVII.

C. H. FERNALD.—A synonymical catalogue of the described Tortricidae of North America, north of Mexico. <Trans. Amer. Entom. Soc. Vol. X, 1882, pp. 1-64.

TINEIDÆ.

B. CLEMENS.—The Tineina of North America, by the late Dr. Brackenridge Clemens. Being a collected edition of his writings on that group of insects. With notes by the editor, H. T. Stainton. London, Van Voorst, 1872, pp. 15+282.

V. T. CHAMBERS.—Index to the described Tineina of the United States and Canada. <Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, 1878, pp. 125-167.

THOMAS, LORD WALSINGHAM.—North American Coleophoræ. <Trans. Ent. Soc. London, 1882, pp. 429-442, Pl. XVII.

THOMAS, LORD WALSINGHAM.—A revision of the genera *Aerolophus*, *Poey* and *Anaphora*, Clem. <Trans. Entom. Soc. London, 1887, pp. 137-173, Pls. VII, VIII.

DIPTERA.

I.—CATALOGUES.

C. R. OSTEN SACKEN.—Catalogue of the described Diptera of North America. Washington, Smithsonian Institution, 1858. <Smithsonian Miscell. Collections, Vol. III.

C. R. OSTEN SACKEN.—Catalogue of the described Diptera of North America. [Second edition.] Washington, Smithsonian Institution, 1878. <Smithsonian Miscell. Collections, 270.

This completely supersedes the first edition and contains by far more than a synonymical reference list of the North American Diptera.

II.—GENERAL WORKS ON CLASSIFICATION.

F. W. MEIGEN.—Systematische Beschreibung der bekannten europäischen zweiflügeligen Insecten. 7 vols. Aachen und Hamm, 1818-'38.

Although only dealing with the European fauna and now antiquated and superseded in many parts, this work is still the foundation of the modern classification of Diptera.

C. R. W. WIEDEMANN.—Ausserenropäische zweiflügelige Insecten. 2 vols. Hamm, 1828-'30.

A continuation of Meigen's work, and containing descriptions of many genera and species belonging to the North American fauna.

J. MACQUART.—Diptères exotiques nouveaux ou peu connus. 2 vols. in 5 parts and 5 supplements. Paris, 1838-'55.

Contains descriptions of many North American genera and species.

J. R. SCHINER.—Fauna Austriaca. Die Fliegen (Diptera). Nach der analytischen Methode bearbeitet, mit der Charakteristik sämtlicher europäischer Gattungen, der Beschreibung aller in Deutschland vorkommenden Arten und der Aufzählung aller bisher beschriebenen europäischen Arten. 2 vols., Wien, 1862-'64.

Although dealing with the European fauna, this work is very useful on account of the analytical tables of families and genera.

H. LOEW AND C. R. OSTEN-SACKEN.—Monographs of the Diptera of North America. (Smithsonian Miscellaneous Collections.) 4 parts. Washington, Smithsonian Institution, 1862-'72.

The several monographs will be found enumerated under the respective families.

- H. LOEW.—*Diptera Americae septentrionalis indigena*. 2 parts. Berlin, 1861-'72. (Originally published in 10 centuriæ in the *Berliner Entomol. Zeitschrift*.)

Descriptions of 1,000 North American Diptera, but without synoptic arrangement.

- C. R. OSTEN-SACKEN.—*Western Diptera: Descriptions of new genera and species of Diptera from the region west of the Mississippi and especially from California*. <Bull. U. S. Geol. and Geogr. Survey of the Territories, Vol. III, 1877, pp. 189-354.

- F. BRAUER.—*Die Zweiflügler des Kaiserlichen Museums zu Wien*. I-III. Wien, 1880-'83.

Important contributions to the classification of the Diptera.

III.—MONOGRAPHS AND SYNOPSES.

CECIDOMYIDÆ.

- J. WINNERTZ.—*Beitrag zu einer Monographie der Gallmücken*. <Linnæa Entomologica, Vol. VIII, 1853, 4 plates.

- R. OSTEN SACKEN.—*On the North American Cecidomyiæ*. <Monographs of the Diptera of North America, by H. Loew and Osten Sacken, Part I, No. 5, 1862, pp. 173-205.

- B. D. WALSH.—*On the insects, Coleopterous, Hymenopterous, and Dipterous, inhabiting the galls of certain species of Willow*. Diptera. <Proc. Ent. Soc. Phil., Vol. III, 1864, pp. 543-644; Vol. VI, 1866, pp. 223-229.

- J. VON BERGENSTAMM AND PAUL LOEW.—*Synopsis Cecidomyidarum*. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XXVI, 1876, pp. 1-104.
A synopsis of all the literature of the family.

MYCETOPHILIDÆ.

- J. WINNERTZ.—*Beitrag zu einer Monographie der Pilzmücken*. <Verh. k. k. zool.-bot. Ges. in Wien, 1863, pp. 637-694.

Useful for determination of genera; no American species are described.

- J. WINNERTZ.—*Beitrag zu einer Monographie der Sciarinen*. <Verh. k. k. zool.-bot. Ges. in Wien, 1867.

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- H. LOEW.—*Revision der Blepharocerida*. <Schles. Zeitschr. f. Entom., neue Folge, Heft VI, Breslau, 1877.

TIPULIDÆ.

- C. R. OSTEN SACKEN.—*New genera and species of North American Tipulidæ with short palpi, with an attempt at a new classification of the tribe*. With two plates. <Proc. Ac. Nat. Sc. Phil., 1859, pp. 197-256.

- R. OSTEN SACKEN.—On the North American Tipulidæ (Part First).
 <Monographs of the Diptera of North America, Part IV, 1869.
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 Cylindrotomina and Ptychopterina.

- C. R. OSTEN SACKEN.—Studies on Tipulidæ. Part I. Review of the
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XYLOPHAGIDÆ.

- Fr. BRAUER.—Versuch einer Charakteristik der Gattungen der Notacanthæ (Ltr.), mit Rücksicht auf die im Kaiserlichen Museum befindlichen von Dr. J. R. Schiner aufgestellten neuen Gattungen.
 <Die Zweiflügler des Kais. Museums zu Wien, Vol. II, 1882, pp. 3-35.

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- S. W. WILLISTON.—On the classification of North American Diptera.
 (Third paper.) <Entomolog. Amer., Vol. I, 1885, pp. 114-116.
 Tables for distinguishing the families Stratiomyidæ and Xylophagidæ and
 oscillant genera; table of the genera of Xylophagidæ.

STRATIOMYIDÆ.

- S. W. WILLISTON.—On the classification of North American Diptera
 (Third paper.) <Entomolog. Amer., Vol. I, 1885, pp. 114-116 and
 152-155.

Tables of the subfamilies and genera of the family.

TABANIDÆ.

- C. R. OSTEN SACKEN.—Prodrome of a monograph of the Tabanidæ of
 the United States. <Memoirs of the Boston Soc. of Nat. Hist., Vol.
 II, 1875-778.

Part I. The genera Pangonia, Chrysops, Silvius, Hæmotopota, Diabasis (*l. c.*,
 pp. 365-397). Part II. The genus Tabanus, with an Appendix and Index
 (*l. c.*, pp. 421-479). Supplement (*l. c.*, pp. 555-560).

- S. W. WILLISTON.—On the classification of North American Diptera.
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III.—MONOGRAPHS AND SYNOPSES.

TERMITIDÆ.

H. A. HAGEN.—Monographie der Termiten. <Linnæa entomol., Vols. X, XII, and XIV, 1855-'60.

EMBIIDÆ.

H. A. HAGEN.—Monograph of the Embidina. <Canadian Entomol. Vol. XVII, 1885.

Only one species of this family has hitherto been found in the United States.

PSOCIDÆ.

H. A. HAGEN.—Beiträge zur Monographie der Psociden. <Stettiner entomol. Zeit., Vols. XLIII and XLIV, 1882-'83.

PERLIDÆ.

F. J. PICTET.—Histoire naturelle générale et particulière des insectes Neuroptères. Première monographie: Famille des Perlides. Genève, 1841-'42.

EPHEMERIDÆ.

F. J. PICTET.—Histoire naturelle générale et particulière des insectes Neuroptères. Seconde monographie: Famille des Ephémérines. Genève, 1843-'45.

BENJ. D. WALSH.—List of the Pseudoneuroptera of Illinois contained in the cabinet of the writer, with descriptions of over forty new species, and notes on their structural affinities. <Proc. Ac. Nat. Sc. Philadelphia, 1862, pp. 361-402.

This paper contains, on pp. 367, 368, a table of the genera of Ephemeridæ.

BENJ. D. WALSH.—Observations on certain North American Neuroptera, by H. Hagen, M. D., of Königsberg, Prussia; translated from the original French MS., and published by permission of the author, with notes and descriptions of about twenty new North American species of Pseudoneuroptera. <Proc. Entom. Soc. Phila., Vol. II, 1863-64, pp. 167-272.

Contains a modification of the table of genera of Ephemeridæ, pp. 195, 196; a table of the subgenera of Gomphus, p. 253; and a "Synoptical table of the subfamilies of the family Odonata," pp. 259, 260.

A. E. EATON.—A monograph on the Ephemeridæ. Part 1. The nomenclature of the Ephemeridæ. <Trans. Entom. Soc. London, 1871, pp. 1-164, 6 pl.

A. E. EATON.—A Revisional Monograph of recent Ephemeridæ, or Mayflies. <Trans. Linn. Soc. London, 1883-'86.

Four parts have hitherto been published.

ODONATA.

E. DE SELYS LONGCHAMPS ET H. HAGEN.—Monographie des Caloptérygines. Bruxelles, 1854.

E. DE SELYS LONGCHAMPS ET H. HAGEN.—Monographie des Gomphines. Bruxelles, 1858.

E. DE SELYS LONGCHAMPS.—Synopsis des Agrionines. 6 parts. Bruxelles, 1860-'65.

E. DE SELYS LONGCHAMPS.—Synopsis des Cordulines. Bruxelles, 1871.

H. A. HAGEN.—Synopsis of the Odonata of America. <Proc. Boston Soc. Nat. Hist., Vol. XVIII, 1875, pp. 20-96.

Omitting the subfamily Agrionina.

HEMEROBIDÆ.

G. TH. SCHNEIDER.—Symbola ad monographiam generis Chrysopæ Leach. Vratislaviæ, 1851.

H. A. HAGEN.—Hemerobidarum synopsis synonymica. <Stettiner entomol. Zeit., 1866, pp. 369-462.

H. A. HAGEN.—Monograph of the Hemerobidæ. <Part I, Proc. Boston Soc. Nat. Hist., Vol. XXIII, 1886, pp. 250-269; Pt. II, *l. c.*, pp. 276-292.

Apparently not yet completed.

PANORPIDÆ.

- J. O. WESTWOOD.—Monograph of the genus *Panorpa*. <Trans. Entom. Soc. London, Vol. IV, p. 1.

PHRYGANIDÆ.

- R. McLACHLAN.—Notes on North American Phryganidæ, with especial reference to those contained in the collection of the British Museum. <Entom. Annual for 1863, pp. 155–163.
Contains a list of North American Phryganids.
- H. A. HAGEN.—Phryganidarum Synopsis synonymica. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XIV, 1864, pp. 799–890.
- H. A. HAGEN.—Beiträge zur Kenntniss der Phryganiden. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XXIII, 1873, pp. 377–452.
- H. A. HAGEN.—[On the Phryganidæ.] <Proc. Boston Soc. Nat. Hist., Vol. XV, 1873, pp. 384, 385.
A list of the North American species.
- A. E. EATON.—On the Hydroptilidæ, a family of the Trichoptera <Trans. Entom. Soc. London, 1873, pp. 125–151.
Gives a list of the species, and synopsis of genera.

MALLOPHAGA.

- H. DENNY.—Monographia Anoplurorum Britanniae. London, 1842, 26 pl.
- C. G. A. GIEBEL.—Insecta epizoa. Die auf Säugethieren und Vögeln schmarotzenden Insekten. Nach Zeichnungen von C. L. Nitzsch. Leipzig, 1874, 20 pl.
- ANDREW MURRAY.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks. London and New York, 1877.
The Mallophaga (Anoplura) are treated on pp. 375–384.
- P. MÉGNIN.—Les Parasites et les maladies parasitaires chez l'homme, les animaux domestiques et les animaux sauvages avec lesquels ils peuvent être en contact. Insectes, Arachnides, Crustacés. Paris, 1880.
- E. PIAGET.—Les Pédiculines. Description de toutes les espèces observées, enrichie d'espèces nouvelles. Leide, 1880, 56 pl.; Supplement, 1885, 17 pl.
- O. TASCHENBERG.—Die Mallophagen mit besonderer Berücksichtigung der von Meyer gesammelten Arten. Halle, 1882.

THYSANURA.

A. S. PACKARD, JR.—Synopsis of the Thysanura of Essex County, Mass., with descriptions of a few extralimital forms. <Fifth Annual Report of the Trustees of the Peabody Academy of Science for the year 1872, Salem, 1873, pp. 23-51.

JOHN LUBBOCK.—Monograph of the Collembola and Thysanura. London, Ray Society, 1873.

The introduction gives the full bibliography up to date.

ANDREW MURRAY.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks, London and New York, 1877.

The Thysanura are treated of on pp. 401-416.

MYRIAPODA.

I.—CATALOGUES.

No comprehensive catalogue or list have hitherto been published on the North American Myriapods.

II.—COMPREHENSIVE WORKS.

THOMAS SAY.—Descriptions of the Myriapodæ of the United States. <Journ. Ac. Nat. Sc. Phil., Vol. II, 1821, pp. 102-114; Say's Entom. Writings, ed. Le Conte, Vol. II, pp. 24-32.

This is the first paper of importance on the North American Myriapoda.

GEORGE NEWPORT.—Monograph of the class Myriapoda, Order Chilopoda. <Trans. Linnean Soc. of London, Vol. XIX, 1845, pp. 265-302 and 349-439.

C. L. KOCH.—System der Myriapoden. Regensburg, 1847.

C. L. KOCH.—Die Myriapoden. 2 vols. Halle, 1863.

HORATIO C. WOOD, Jr.—On the Chilopoda of North America, with Catalogue of all the specimens in the collection of the Smithsonian Institution. <Journ. Ac. Nat. Sc. Phil., New Ser., Vol. V, 1863, pp. 5-42.

HORATIO C. WOOD, Jr.—The Myriapoda of North America. <Trans. Amer. Philos. Soc., Vol. XIII, 1865, pp. 137-248, 3 pl.

This is the first and only monograph of the Myriapoda published in this country.

ANDREW MURRAY.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks, London and New York, 1877.

ROBERT LATZEL.—Die Myriapoden der Oesterreichisch-Ungarischen Monarchie. Erste Hälfte: Die Chilopoden, Wien, 1880. Zweite Hälfte: Die Symphylen, Pauropoden und Diplopoden, Wien, 1884.

The most recent comprehensive work on this order, and very important from a classificatory standpoint.

A. S. PACKARD, Jr.—On the morphology of the Myriapoda. <Proc. Amer. Philos. Soc., Vol. XXI, 1883, pp. 197-209.

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A complete bibliographical review of the subject, with tables of families and genera.

III.—MONOGRAPHS AND SYNOPSES OF FAMILIES AND GENERA.

PAUROPODA (families *Pauropodidae* and *Eurypauropodidae*).

A. S. PACKARD, JR.—New or rare Neuroptera, Thysanura, and Myriapoda. <Proc. Boston Soc. of Nat. Hist., Vol. XIII, 1870, pp. 405–411.

A. S. PACKARD, JR.—A remarkable Myriapod. <Amer. Natur., Vol. IV, 1870, p. 621.

JOHN A. RYDER.—Discovery of two remarkable genera of minute Myriapoda in Fairmount Park. <Amer. Natur., Vol. XII, 1878, pp. 557, 558.

JOHN A. RYDER.—An account of a new genus of minute Pauropod Myriapods. <Amer. Natur., Vol. XIII, 1879, pp. 603–612.

DIPLOPODA (families *Polyxenidae*, *Polyzonidae*, *Polydesmidae*, *Chordeumidae*, *Lysiopetalidae*, and *Julidae*).

HORATIO C. WOOD.—Descriptions of new species of North American Polydesmidae. <Proc. Ac. Nat. Sc. Phil., 1864, pp. 6–10.

JOHN A. RYDER.—List of the North American species of Myriapods belonging to the family of the Lysiopetalidae, with a description of a blind form from Luray Cave, Virginia. <Proc. U. S. Nat. Mus., Vol. III, 1881, pp. 524–529.

A. S. PACKARD, JR.—A revision of the Lysiopetalidae, a family of Chilognath Myriapoda, with a notice of the genus Cambala. <Proc. Amer. Philos. Soc., Vol. XXI, 1883, pp. 177–197.

CHARLES H. BOLLMAN.—Notes on North American Julidae, with descriptions of new species. <Ann. N. Y. Ac. Sc., Vol. IV, Nos. 1 and 2, pp. 25–44.

CHILOPODA (families *Scutigera*, *Geophilidae*, *Scolopendridae*, and *Lithobiidae*).

LUDWIG KOCH.—Die Myriapodengattung Lithobius. Nürnberg, 1862.
A monograph of the genus, comprising the species of all continents.

A. STUXBERG.—Nya nordamerikanska Lithobier. <Öfversigt k. Vetensk. Acad. Förh., Vol. XXXII, No. 2, 1875, pp. 65–72.

A. STUXBERG.—Lithobioidae Americae borealis. Öfversigt af Nord-Amerikas hittills kända Lithobiider. <Öfversigt k. Vetensk. Acad. Förh., Vol. XXXII, No. 3, 1875, pp. 23–32.

FR. MEINERT.—Myriopoda Musei Cantabrigiensis, Mass. Part I. Chilopoda. <Proc. Amer. Philos. Soc., 1885, pp. 161–233.

Of great value for the study of classification, though containing no synopses.

ARACHNIDA.

I.—CATALOGUES.

No catalogue of the North American forms has so far been published.

II.—COMPREHENSIVE WORKS.

C. W. HAHN AND C. L. KOCH.—Die Arachniden. Nürnberg, 1831-'48, 16 vols. with 563 pl.

H. LUCAS.—Descriptions et figures d'espèces nouvelles d'Arachnides. Paris, 1835-'36.

C. A. DE WALCKENAER.—Histoire naturelle des Insectes (Suites à Buffon). Aptères. Paris, Roret, 1837-'47, 4 vols., with 52 pl.

The first work on general classification of this order, and many North American species are described from drawings by Bosc and Abbot.

N. M. HENTZ.—Descriptions and figures of the Araneides of the United States. <Journ. Boston Soc. Nat. Hist., Vol. IV-VI, 1842-'50.

These papers form the basis of the study of American arachnology. Numerous species are described, but not in synoptic form.

T. THORELL.—On European Spiders. Part I. Review of the European genera of Spiders. Upsala, 1869-'70.

N. M. HENTZ.—Araneæ Americæ septentrionalis. The Spiders of the United States. Edited by J. H. Emerton and E. Burgess. <"Occasional Papers" of the Boston Society of Natural History, 1875.

A reprint of Hentz's papers on North American spiders.

GRAF EUGEN KEYSERLING.—Amerikanische Spinnen aus den Familien Pholcoidæ, Scytodoidæ und Dysderoidæ. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XXVII, 1877, pp. 205-234.

GRAF EUGEN KEYSERLING.—Neue Spinnen aus Amerika. (Six parts.) <Verh. k. k. Zool.-bot. Ges. in Wien, Vols. XXIX-XXXIV, 1879-'84.

E. SIMON.—Les Arachnides de France. Paris, Vols. I-V, 1874-'84.

These two works represent the most recent systems of classification, and are therefore of great general value, although they deal only with the European fauna.

LUCIEN M. UNDERWOOD.—The Progress of Arachnology in America. <Amer. Natur., Vol. XXI, 1887, pp. 963-975.

A very useful review of the bibliography, with synoptic table of the families of the Araneæ.

III.—MONOGRAPHS AND SYNOPSES.

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GRAF E. KEYSERLING.—Beschreibung neuer und wenig bekannter Arten aus der Familie Orbiteke Latr. oder Epeiridæ Sund. <Sitzungsber. d. naturw. Ges. Isis in Dresden, 1863 (1864), pp. 63–154.

J. E. EMERTON.—New England Spiders of the family Epeiridæ. <Trans. Connect. Acad. of Sc, Vol. VI, 1884, pp. 295–342.

THERIDIDÆ.

O. P. CAMBRIDGE.—On some new species of Erigone from North America. Two parts. <Proc. Zool. Soc. London, 1874, pp. 428–442; 1875, pp. 393–405.

J. H. EMERTON.—New England Spiders of the family Therididæ. <Trans. Conn. Acad., Vol. VI, 1882, pp. 1–86.

GRAF E. KEYSERLING.—Die Spinnen Amerikas. II. Therididæ. 1. Hälfte, Nürnberg, 1884; 2. Hälfte, Nürnberg, 1886.

THOMISIDÆ.

GRAF E. KEYSERLING.—Die Spinnen Amerikas. Laterigradæ. Nürnberg, 1880.

ATTIDÆ.

G. W. AND E. G. PECKHAM.—Descriptions of new or little known spiders of the family Attidæ, from various parts of the United States of North America. Milwaukee, 1883.

DRASSIDÆ.

C. L. KOCH.—Die Arachniden-Familie der Drassiden. Nürnberg, 1866–68.

O. P. CAMBRIDGE.—On some new species of Drassides. <Proc. Zool. Soc. London, 1874, pp. 370–419

LYCOSIDÆ.

GRAF E. KEYSERLING.—Ueber amerikanische Spinnen-Arten der Unterordnung Citigradæ. <Verh. k. k. zool.-bot. Ges. Wien, Vol. XXXVI, 1876, pp. 609–708.

J. H. EMERTON.—New England Spiders of the family Lycosidæ. <Trans. Conn. Acad., Vol. VI, 1885, pp. 481–505.

MYGALIDÆ.

ANTON AUSSERER.—Beiträge zur Kenntniss der Arachniden-Familie der Territelariæ Thorell. <Verh. k. k. zool. bot. Ges. Wien, Vol. XXI, 1871, pp. 117-224.

J. T. MOGGIDGE.—Harvesting Ants and Trap-door Spiders, with supplementary descriptions of species by Rev. O. P. Cambridge. London, 1873-'74.

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T. THORELL.—On the classification of Scorpions. <Ann. and Mag. Nat. Hist., Vol. XVII, 1876, p. 1 ff.

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SOLPUGIDÆ.

E. SIMON.—Essai d'une classification des Galéodes. <Ann. Soc. Ent. France, 1879, pp. 93 ff.

FR. KARSCH.—Zur Kenntniss der Galeodiden. <Archiv für Naturgesch., Vol. XLVI, 1880.

J. DUNCAN PUTNAM.—The Solpugidæ of America. Arranged for publication by Herbert Osborn. <Proc. Davenport Ac. Nat. Sc., Vol. III, 1882, pp. 149 ff.

This monograph remained incomplete on account of the death of the author. It contains a complete bibliography on the family.

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HORATIO C. WOOD, Jr.—On the Pedipalpi of North America. <Journ. Acad. Nat. Sc. Philadelphia, 2d ser., Vol. V, 1863, pp. 357-376, Pl. XL.

J. THORELL.—On the classification of Scorpions. <Ann. and Mag. of Nat. Hist., 4th ser., Vol. XVII, 1876, pp. 1 ff.

J. THORELL.—Études Scorpiologiques. <Act. Soc. Ital. d. Sc. Nat., Vol. XIX, 1877, pp. 75 ff.
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FR. KARSCH.—Scorpionologische Beiträge. <Mitth. d. Münchener Entom. Ver., 1879, 2 parts.

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A. MENGE.—Ueber die Scheerenspinnen Chernetidæ. Danzig, 1855.

H. A. HAGEN.—Synopsis Pseudoscorpionidum, synonymica. <Proc. Boston Soc. Nat. Hist., Vol. XIII, 1870, pp. 263–272.

LUDWIG KOCH.—Uebersichtliche Darstellung der europäischen Chernetiden. Nürnberg, 1873.

* PHALANGIDÆ.

HORATIO C. WOOD, JR.—On the Phalangæe of the United States of America. <Commun. of the Essex Inst., Vol. VI, 1868, pp. 10–40.

J. THORELL.—Conspectus familiarum et generum Europæorum ordinis Opilium. <Ann. del Mus. civico d. Storia nat. de Genova, 1876, pp. 462 ff.

E. SIMON.—Essai d'une classification des Opiliones Mecostethi. <Ann. Soc. Entom. de Belgique, Vol. XXII, 1880, pp. 183–241.

Acarina.

A. DUGÈS.—Recherches sur l'ordre des Acariens (III^{me} Mémoire). <Ann. des Sc. Nat., II^{me} sér., Vol. I, 1836, Zoologie, p. 18 ff.

LÉON DUFOUR.—Descriptions et figures de quelques parasites de l'ordre des Acariens. <Ann. des Sc. Natur., Vol. XI, 1839, p. 274 ff.

H. NICOLET.—Histoire naturelle des Acariens qui se trouve aux environs de Paris. <Archives du Muséum d'histoire nat. de Paris, Vol. VII, 1854–'55.

C. G. GIEBEL.—Insecta Epizoa. Die Parasiten der Säugethiere und Vögel. Leipzig, 1874.

P. MÉGNIN.—Mémoire sur les Métamorphoses des Acariens en général et en particulier sur celles des Trombidions. <Ann. des Sc. Nat., Sér. VI, Vol. IV, 1876, Article 5.

P. MÉGNIN.—Mémoire sur l'organisation et la distribution zoologique des Acariens de la famille des Gamasidés. <Journ. d'Anatomie et de Physiologie, 1876, pp. 288–336.

J. P. MÉGNIN.—Monographie de la Tribu des Sarcoptides Psorique, subdivision de la famille des Sarcoptides, ordre des Acariens. <Revue et Magasin de Zoologie, 1877.

- P. CRAMER.—Grundzüge zur Systematik der Milben. <Wiegmann Archiv für Naturgesch., 1877, pp. 215-248.
- ANDREW MURRAY.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks, London and New York, 1877.
- PIERRE MÉGNIN.—Mémoire sur les Cheylétides Parasites. <Journ. d'Anatomie et de Physiologie, 1878, p. 1 ff.
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- G. HALLER.—Die Milben als Parasiten der Wirbellosen, in's Besondere der Arthropoden. Halle a. S., 1880.
- ANTONIO BERLESE.—Acari, Miriopodi e Scorpioni Italiani. Padova, 1882 and subsequent years (not yet completed).
- H. GARMAN.—The Phytognathi and other injurious plant mites. <Twelfth Rep. of the State Entom. on the Nox. and Benef. Insects of the State of Ills., 1883, pp. 123-143.
- Besides the two papers just cited the American literature on the Mites furnishes only descriptions or observations concerning single species, or papers of a more popular character, which I cannot enumerate here; and the student is referred to the following European works, which have more or less contributed toward our knowledge of the classification of the Acarina.
- L. KARPELLES.—Beiträge zur Naturgeschichte der Milben. <Berlin. entom. Zeitsch., Vol. XXVIII, 1884, pp. 1-34.
- ANTONIO BERLESE.—Acarorum Systematis Specimen. <Bull. Soc. Ent. Ital., Vol. XVII, 1885, p. 121 ff.
- HERBERT OSBORN.—Preliminary List of the species of Acarina of North America. <Canad. Entom., Vol. XVIII, 1886, pp. 4-12.

LIST OF THE MORE IMPORTANT PERIODICALS CITED IN THIS BULLETIN.

AMERICAN PERIODICALS.

- THE AMERICAN NATURALIST. A monthly journal devoted to the natural sciences in their widest sense (20 volumes published up to 1887.) (Now published by Leonard Scott Publication Co., Philadelphia.)
- ANNALS OF THE LYCEUM OF NATURAL HISTORY OF NEW YORK (8 volumes, 1824-'67).
- BULLETIN OF THE BROOKLYN ENTOMOLOGICAL SOCIETY (7 volumes, 1878-'85).

- BULLETIN OF THE BUFFALO SOCIETY OF NATURAL HISTORY (4 volumes completed, beginning with 1874; the fifth in course of publication).
- THE CANADIAN ENTOMOLOGIST (edited by William Saunders and lately by J. S. Bethune; 19 volumes published up to the end of 1887. Published at London, Ont.)
- ENTOMOLOGICA AMERICANA. Published by the Brooklyn Entomological Society at Brooklyn, N. Y. (2 volumes completed since 1885; the third in course of publication).
- JOURNAL OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA (commencing with 1817).
- MEMOIRS OF THE BOSTON SOCIETY OF NATURAL HISTORY (commencing with 1866).
- PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA (beginning with 1841).
- PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY OF PHILADELPHIA (beginning with 1860).
- PROCEEDINGS OF THE BOSTON SOCIETY OF NATURAL HISTORY (commencing with 1841).
- PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF PHILADELPHIA (6 volumes, 1861-'67).
- PAPILIO. Devoted exclusively to Lepidoptera. Organ of the New York Entomological Club (4 volumes, 1881-'84).
- PSYCHE.—Organ of the Cambridge Entomological Club (4 volumes issued up to date. Published at Cambridge, Mass).
- TRANSACTIONS OF THE ACADEMY OF SCIENCE OF SAINT LOUIS (4 volumes hitherto published).
- TRANSACTIONS OF THE AMERICAN ENTOMOLOGICAL SOCIETY and proceedings of the Entomological Section of the Academy of Natural Sciences (beginning with 1868; 14 volumes published up to 1887. Published at Philadelphia.)
- TRANSACTIONS OF THE AMERICAN PHILOSOPHICAL SOCIETY OF PHILADELPHIA (2nd series beginning with 1818).
- SMITHSONIAN MISCELLANEOUS COLLECTIONS (Smithsonian Institution, Washington, D. C.; beginning 1862).
- BULLETINS OF THE UNITED STATES NATIONAL MUSEUM (Department of the Interior; beginning with 1875).

PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM (Department of the Interior; beginning with 1878).

BULLETINS OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES, F. V. Hayden in charge (Department of the Interior; beginning with 1875).

REPORTS OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES (Department of the Interior; beginning with 1867).

FOREIGN PERIODICALS.

ANNALES DE LA SOCIÉTÉ ENTOMOLOGIQUE DE BELGIQUE (beginning with 1860. Published at Bruxelles).

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BERLINER ENTOMOLOGISCHE ZEITSCHRIFT (commencing with 1857).

DEUTSCHE ENTOMOLOGISCHE ZEITSCHRIFT. Herausgegeben von Dr. G. Kraatz. Berlin (beginning with 1881).

ENTOMOLOGISCHE ZEITUNG. Herausgegeben von dem entomologischen Verein zu Stettin (beginning with 1840).

LINNÆA ENTOMOLOGICA. Herausgegeben vom entomologischen Verein zu Stettin (16 volumes. Berlin, 1846-'66.)

ÖFVERSIGT AF KONGL. SVENSKA VETENSKAPS ACADEMIENS FÖRHANDLINGAR (beginning with 1844. Published at Stockholm).
Proceedings of the Royal Swedish Academy of Sciences.

SITZUNGSBERICHTE DER MATHEMATISCH-NATURWISSENSCHAFTLICHEN CLASSE DER KAISERLICHEN ACADEMIE DER WISSENSCHAFTEN ZU WIEN (beginning with 1848).

TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON (beginning with 1791).

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VERHANDLUNGEN DER ZOOLOGISCH-BOTANISCHEN GESELLSCHAFT IN WIEN (beginning with 1852).

ZEITSCHRIFT FÜR DIE ENTOMOLOGIE. Herausgegeben von E. F. Germar (5 volumes. Leipzig, 1839-'44).

MITTHEILUNGEN DER SCHWEIZERISCHEN ENTOMOLOGISCHEN GESELLSCHAFT. Bulletin de la Société entomologique suisse (7 volumes published up to 1887. Published at Geneva).

ANNALS AND MAGAZINE OF NATURAL HISTORY. London (beginning with 1838).

REVUE ET MAGASIN DE ZOOLOGIE PURE ET APPLIQUÉE. Paris (beginning with 1839).

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LIST OF WORKS ON ECONOMIC ENTOMOLOGY.

1. HARRIS, T. W., *Insects Injurious to Vegetation*. (Flint edition.) New York, Orange Judd Co. \$4 or \$6. (First edition, Cambridge, 1841.)
2. FITCH, ASA, *Reports of the State Entomologist of New York*. I-XIV, Albany, 1855-'70. (For a full account of these, see First Annual Report, by J. A. Lintner, State Entomologist of New York, pp. 294-297.)
3. *The Practical Entomologist*. Vols. I and II. Published by the Entomological Society of Philadelphia, 1865-'67.
4. *The American Entomologist*, edited by B. D. Walsh and C. V. Riley. Vol. I. Saint Louis, Mo., 1868. (Out of print.)
5. *The American Entomologist and Botanist*, edited by C. V. Riley and Dr. George Vasey. Vol. II. Saint Louis, Mo., 1870.
6. *The American Entomologist*, edited by C. V. Riley. Vol. III., [Second series. Vol. I.] New York, Hub Publishing Co., 1880.
7. WALSH, B. D., *Annual Report on the Noxious Insects of the State of Illinois*. Chicago, Prairie Farmer Co. Steam Print, 1868.
8. RILEY, C. V., *Reports of the State Entomologist of Missouri*. I-IX, Jefferson City, 1869-'77.
9. LE BARON, WILLIAM, *Reports of the State Entomologist of Illinois*. I-IV, Springfield, 1871-'74.
10. THOMAS, CYRUS, *Reports of the State Entomologist of Illinois*. I-VI, Springfield, 1876-'81.
11. LINTNER, J. A., *Reports of the State Entomologist of New York*. I-III, Albany, 1882-'86.
12. FORBES, S. A., *Reports of the State Entomologist of Illinois*. I-III, Springfield, 1883-'85.

13. FORBES, S. A., Miscellaneous Essays on Economic Entomology. (Published instead of Annual Report. Springfield, Ill., 1886.)
14. TREAT, MARY, Injurious Insects of the Farm and Garden. New York, Orange Judd Co., 1882. (A small work compiled from Riley's reports, and costing \$2.)
15. SAUNDERS, WILLIAM, Insects Injurious to Fruits. Philadelphia, J. B. Lippincott & Co., 1883. \$3.
16. COOKE, MATTHEW, Injurious Insects of the Orchard, Vineyard, etc. Sacramento, 1883. (8vo, pp. 472.)
17. VAN BENEDEN, P. J., Animal Parasites and Messmates. New York, D. Appleton & Co., 1876. \$1.50. International Scientific Series.
18. Reports of the Entomologists of the U. S. Department of Agriculture, T. Glover (1863-1878), J. H. Comstock (1879-1880), and C. V. Riley (1878-1879, 1880 to date).
19. Bulletins of the Division of Entomology of the U. S. Department of Agriculture, C. V. Riley, Entomologist (1883 to date).
20. Reports and Bulletins of the U. S. Entomological Commission.
21. CURTIS, JOHN, Farm Insects. London, Blackie & Son, 1860.
22. ORMEROD, ELEANOR A., Manual of Injurious Insects, and Methods of Prevention, etc. London and Edinburgh, 1881. (A small work, costing about \$1.50.)
25. KALTENBACH, J. H., Die Pflanzenfeinde aus der Classe der Insekten. 8vo. Stuttgart, 1874. (A useful work for determining what insects infest plants in Europe.)

LIST OF ENTOMOLOGICAL WORKS PUBLISHED BY THE U. S. ENTOMOLOGICAL COMMISSION AND BY THE U. S. DEPARTMENT OF AGRICULTURE.

U. S. ENTOMOLOGICAL COMMISSION.

(Members of the Commission: C. V. Riley, A. S. Packard, jr., and Cyrus Thomas.)

Bulletin No. 1.—Destruction of the young or unfledged Locusts (*Caloptenus spretus*). (1877.) [pp. 15.]

Bulletin No. 2.—On the Natural History of the Rocky Mountain Locust and on the habits of the young or unfledged Insects as they occur in the more fertile country in which they will hatch the present year. (1877.) [pp. 14, figs. 10.]

Bulletin No. 3.—The Cotton Worm. Summary of its Natural History, with an Account of its Enemies, and the best Means of controlling it; being a Report of Progress of the Work of the Commission. By Chas. V. Riley, M. A., Ph. D. (1880.) [pp. 144, figs. 84, plates I.]

Bulletin No. 4.—The Hessian Fly. Its Ravages, Habits, Enemies, and Means of preventing its Increase. By A. S. Packard, jr., M. D. (1880.) [pp. 43, figs. 1, plates II., maps I.]

Bulletin No. 5.—The Chinch Bug. Its History, Characters, and Habits, and the Means of destroying it or counteracting its Injuries. By Cyrus Thomas, Ph. D. (1879.) [pp. 44, figs. 10, maps I.]

Bulletin No. 6.—General Index and Supplement to the nine Reports on the Insects of Missouri. By Charles V. Riley, M. A., Ph. D. (1881.) [pp. 177.]

Bulletin No. 7.—Insects injurious to Forest and Shade Trees. By A. S. Packard, jr., M. D. (1881.) [pp. 275, figs. 100.]

First Annual Report for the year 1877, relating to the Rocky Mountain Locust and the best Methods of preventing its Injuries and of guarding against its Invasions, in pursuance of an Appropriation made by Congress for this purpose. With maps and illustrations. (1878.) [pp. 477+294, figs. 111, plates V, maps I.]

Second Report for the years 1878 and 1879, relating to the Rocky Mountain Locust and the Western Cricket, and treating of the best Means of subduing the Locust in its permanent Breeding-grounds, with a view of preventing its Migrations into the more fertile Portions of the trans-Mississippi country, in pursuance of Appropriations made by Congress for this purpose. With Maps and Illustrations. (1880.) [pp. xviii+322+22, figs. 10, plates XVII, maps 7.]

Third Report relating to the Rocky Mountain Locust, the Western Cricket, the Army Worm, Canker Worms, and the Hessian Fly; together with Descriptions of Larvæ of injurious Forest Insects, Studies on the embryological Development of the Locust and of other Insects, and on the systematic Position of the Orthoptera in Relation to other Orders of insects. With Maps and Illustrations. (1883.) [pp. xviii+347+91, figs. 14, plates LXIV, maps 3].

Fourth Report, being a revised Edition of Bulletin No. 3, and the Final Report on the Cotton Worm and Boll Worm. By Charles V. Riley, Ph. D. (1885.) [pp. xxxviii+399+147, figs. 45, plates LXIV, maps 2.]

U. S. DEPARTMENT OF AGRICULTURE.

The annual reports of the Entomologist are contained in the corresponding annual reports of the Department of Agriculture. A limited author's edition, separately bound, and with table of contents and index is published each year.

Division of Entomology, Bulletin No. 1.—Reports of Experiments, chiefly with Kerosene, upon the Insects injuriously affecting the Orange Tree and the Cotton Plant, made under the Direction of the Entomologist. (1883.) [pp. 62.]

Division of Entomology, Bulletin No. 2.—Reports of Observations on the Rocky Mountain Locust and Chinch Bug, together with Extracts from the Correspondence of the Division on Miscellaneous Insects. (1883.) [pp. 36.]

Division of Entomology, Bulletin No. 3.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. With plates. (1883.) [pp. 75, plates III.]

Division of Entomology, Bulletin No. 4.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist, together with Extracts from Correspondence on miscellaneous Insects. (1884.) [pp. 102, figs. 4.]

Bureau of Entomology, Bulletin No. 5.—Descriptions of North American Chalcididae from the Collections of the U. S. Department of Agriculture and of Dr. C. V. Riley, with biological Notes. [First paper.] Together with a List of the described North American Species of the Family. By L. O. Howard, M. Sc., Assistant, Bureau of Entomology. (1885.) [pp. 47.]

Division of Entomology, Bulletin No. 6.—The imported Elm-leaf Beetle. Its Habits and Natural History, and Means of counteracting its Injuries. (1885.) [pp. 18, figs. 1, plates I.]

Division of Entomology, Bulletin No. 8.—The Periodical Cicada. An Account of *Cicada septendecim* and its tredicim Race, with a Chronology of all of the broods known. By Charles V. Riley, Ph. D. (1885.) [pp. 46, figs. 8.]

Division of Entomology, Bulletin No. 9.—The Mulberry Silk-worm; being a Manual of Instructions in Silk-culture. By Charles V. Riley, M. A., Ph. D. (1886.) [pp. 65, figs. 29, plates II.]

Division of Entomology, Bulletin No. 10.—Our Shade Trees and their Insect Defoliators. Being a Consideration of the four most injurious Species which affect the Trees of the Capital; with Means of destroying them. By Charles V. Riley, Entomologist. (1887.) [pp. 75, figs. 27.]

Division of Entomology, Bulletin No. 11.—Reports of Experiments with various Insecticide Substances, chiefly upon Insects affecting garden Crops, made under the Direction of the Entomologist. (1886.) [pp. 34.]

- Division of Entomology, Bulletin No. 12.*—Miscellaneous Notes on the work of the Division of Entomology for the Season of 1885; prepared by the Entomologist. (1886.) [pp. 45, plates I.]
- Division of Entomology, Bulletin No. 13.*—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (With illustrations.) (1887.) [pp. 78, figs. 4.]
- Division of Entomology, Bulletin No. 14.*—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (1887.) [pp. 62, figs. 2, plates I.]
- Division of Entomology, Bulletin No. 15.*—The Icerya, or Fluted Scale, otherwise known as the Cottony Cushion-scale. (Reprint of some recent Articles by the Entomologist and of a Report from the Agricultural Experiment Station, University of California.) (1887.) [pp. 40.]
- Division of Entomology, Bulletin No. 16.*—The Entomological Writings of Dr. Alpheus Spring Packard. By Samuel Henshaw. (1887.) [pp. 49.]
- Division of Entomology, Bulletin No. 17.*—The Chinch Bug: A general Summary of its History, Habits, Enemies, and of the Remedies and Preventives to be used against it. By L. O. Howard, M. S., Assistant Entomologist. (1888.) [pp. 48, figs. 10.]
- Report on Cotton Insects.* By J. Henry Comstock. (1879.) [pp. 511, figs. 77, plates III.]
- Special Report, No. 11.*—The Silkworm; being a brief Manual of Instructions for the Production of Silk. Prepared, by Direction of the Commissioner of Agriculture, by C. V. Riley, M. A., Ph. D., Entomologist. (First ed., 1879; fifth ed., 1885.) [p. 37, figs. 8.]
- Special Report, No. 35.*—Report on Insects injurious to Sugar Cane. Prepared, under Direction of the Commissioner of Agriculture, by J. Henry Comstock, Entomologist. (1881.) [pp. 11, figs. 3.]
- Division of Entomology. Insects Affecting the Orange.*—Report on the Insects affecting the Culture of the Orange and other Plants of the Citrus Family, with practical Suggestions for their Control or Extirpation. By H. G. Hubbard. (1885.) [pp. x+227, figs. 95, plates XIV.]

NOTE.—During the years 1864 to 1876, inclusive, the Department of Agriculture published regularly monthly reports, mainly statistical in their character (replaced since 1876 by the series of monthly "Crop Reports"), but which contained many short articles by the Entomologist, Townend Glover. None of these articles would come within the scope of the present bulletin, and the insects treated of may be ascertained by reference to the "General Index of the Agricultural Reports of the Patent Office and of the Department of Agriculture, from 1837 to 1876." Washington, 1879.

HOW TO OBTAIN ENTOMOLOGICAL BOOKS AND PAMPHLETS.

Comparatively few of the works treating of the classification of North American insects have been published as separate books; but such as have been so published, if of comparatively recent date, can be obtained through the regular book trade. By far the greater number of the monographs and synopses mentioned in the preceding pages have been published in scientific periodicals and transactions of scientific societies. These periodicals and transactions can be obtained through the societies which publish them and through the publishers; but, in the case of transactions, single volumes, and more especially single papers, are seldom sold, and the older volumes are liable to be out of print. Moreover the expense attending the purchase of all of the periodicals containing the publications on a given order of insects will be so great as to put them beyond the reach of most entomologists. The custom of placing at the disposal of authors a number of separate copies of their papers overcomes this difficulty to some extent and creates a small supply. Thus it often happens that a person interested can obtain a copy of a scientific paper by addressing the author personally. Many of these separate copies also get into the possession of dealers in second-hand books, and can be purchased from them. The American Entomological Society of Philadelphia and also a few other societies here and in Europe offer for sale from their duplicates many of these authors' extras, and in some cases publish lists. There are, moreover, certain business establishments which make a specialty of the sale of works and pamphlets on Natural History, including Entomology, and it is chiefly through such establishments that the student is enabled to secure the larger portion of the works needed. In America there is at present but one of these special dealers of any prominence, viz, Dr. A. E. Foote, of 1223 Belmont avenue, Philadelphia, Pa. But in Europe there are several of considerable reputation; among these we may mention:

- R. Friedlaender & Sohn, Carlstrasse, 11, Berlin, Germany.
- Ed. André, 21 Boulevard Bretonnière, Beaune (Côte-d'Or), France.
- H. W. Schmidt, Rannische Strasse, Nr. 1, Halle a. S., Germany.
- J. B. Baillière et fils, 19, Rue Hautefeuille, Paris, France.
- Oswald Weigel, Königsstrasse, 1, Leipzig, Germany.
- U. Hoepli, Corso Vitt. Eman., 37, Milan, Italy.
- Otto Harrassowitz, Querstrasse, 14, Leipzig, Germany.
- William Wesley & Son, 28 Essex street, Strand, London, England.

All of these firms publish catalogues, and in writing to them the entomological catalogue should be especially asked for. There are two firms in New York which act as agents for all of these houses, and works can be ordered through them or catalogues obtained from them. These are

B. Westermann & Co., 838 Broadway, New York, and Gustav E. Stechert, 766 Broadway, New York.

By subscribing to the entomological periodicals published in this country (a matter of but slight expense) the student may keep abreast of the current literature. Short book reviews or notes published in our periodicals call attention to the more important publications in other countries. Moreover, the *Zoölogischer Anzeiger*, edited by Prof. J. Victor Carus, in Leipzig, Germany, and published every fortnight, gives a tolerably complete bibliography of the current entomological literature at intervals of about six or eight weeks. The "*Nature Novitates*," published every fortnight by R. Friedlaender & Sohn, Carlstrasse, 11, Berlin, Germany, gives the titles of most recent works and pamphlets.

There are also three great annual publications, viz: "*Die Fortschritte auf dem Gebiet der Entomologie*," published in Wiegmann's "*Archiv für Naturgeschichte*"; "*The Zoölogical Record*," published by the Zoölogical Record Society, in London, England; and the "*Zoölogische Jahresberichte*," published by the Zoölogical Station at Naples, Italy, which give the full literature of the previous year, discussing the more important papers and giving a list of the new species, besides other information. One or the other of these three publications is almost indispensable to the student in any branch of Zoölogy, and ought to be found in every public library in the country. Unfortunately, only a year ago the editors of the "*Zoölogische Jahresberichte*" found it necessary, in order to reduce expenses, to curtail the scope of the work; so that, beginning with the year 1887, this publication no longer contains titles upon systematic and classificatory Zoölogy. Only biological titles are now published, but the series up to 1887 is the most complete thing of its kind.

A not inconsiderable portion of the North American literature on the classification of insects has been published by the General Government through various channels, and foremost among them are the Smithsonian Institution, the U. S. Department of Agriculture, the U. S. National Museum, the U. S. Geological and Geographical Survey, and the reports of the various surveys of the Territories. Many of these publications are distributed free of cost to any one applying for them; while others, like certain of the Smithsonian publications, are sold at a moderate price to cover the cost of publication. Many of them are out of print, and can only be obtained through natural history book-dealers. The firms mentioned above will have many of them, and Lowdermilk & Co., of Washington, D. C., who make a specialty of Government publications, are always able to furnish many more.

Of the more general works, some of them can be obtained direct from the publishers, and in such cases the publishers are mentioned in the general list. The older ones are mostly out of print and can only be obtained from second-hand dealers. The current State reports of Lint-

ner and Forbes can be obtained from the secretaries of the respective State Agricultural Societies at Albany, N. Y., and Springfield, Ill., while the reports of the Entomologists of the newly established State Experiment Stations, of which a large number will soon be published, can be obtained from the directors of the respective Stations. The older reports of the State Entomologist of Missouri and the State Entomologists of Illinois (Walsh, Le Baron, and Thomas) are all out of print and can only be obtained by purchase from second-hand dealers. The same may be said of the well-known and often quoted reports of Dr. Fitch, which were published with the old volumes of the Transactions of the New York State Agricultural Society.

U.S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 20.

THE
ROOT-KNOT DISEASE

OF THE

PEACH, ORANGE, AND OTHER PLANTS

IN

FLORIDA,

DUE TO THE WORK OF ANGUILLULA.

PREPARED, UNDER THE DIRECTION OF THE ENTOMOLOGIST,

BY

J. C. NEAL, PH. D., M. D.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1889.

Compliments of

J. M. RUSK,

Secretary of Agriculture.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, May 10, 1889.

SIR: I have the honor to transmit for publication Bulletin No. 20 of this Division, being a report of studies and experiments made upon the *Anguillula*, which is the cause of the root-knot disease of the Peach and Orange in Florida, by J. C. Neal, Ph. D., M. D., of Lake City, Fla.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTORY NOTE.

For several years past complaint has been made to the Division of Entomology concerning the damage done by various species of Anguillulidae, which affect the roots of different plants in different sections of the country, and I have frequently been urged, as Entomologist, to investigate the matter. I have always been puzzled to know what reply to make in such cases, as no American investigator has undertaken a systematic study of these Nematodes, and they do not, in a zoölogical sense, strictly belong to the Division work. I have contented myself therefore with recording the various facts of injury to different plants that have come to me in the past twenty years, and some microscopic notes in reference to the specimens. One species seems to do considerable damage to certain plants in greenhouses in the North, while another is equally destructive to the roots of trees and plants in the South, particularly in Florida. Towards the close of the year 1887 the complaints of the damage done by the Florida root-inhabiting species were so numerous that, at the request of the Commissioner of Agriculture, I decided to conduct some investigations as a part of the Division work. The demands upon the resources of the Division arising from its more legitimate investigations have been such that but little time and small funds could be spent in this direction. Dr. J. C. Neal, then of Archer, Fla., but now Entomologist and Botanist of the Florida Agricultural Experiment Station at Lake City, a diligent observer, and associated with me in previous investigations both under the U. S. Entomological Commission and under this Division, was commissioned for five months and instructed to make as careful studies and experiments concerning this pest as it would be possible to make during the short time of his employment. His work was done between February 1 and September 1, 1888, and while I do not claim for Dr. Neal, any more than he would himself claim, special or technical knowledge in this branch of Zoölogy, his work is not without scientific interest. The investigations have been, however, from a practical stand-point, and the results more than justify the slight expenditure. The Bulletin makes no pretense to be a scientific treatise on the life history of these worms, but is in the main an effort to ascertain a suitable remedy. The general literature on the subject has not been at Dr. Neal's command, and my

time is so fully occupied otherwise that I can do little or nothing at present in the way of identification of species or of comparing Dr. Neal's results with those of European investigators, which, as a matter of fact, are of little practical importance. The study of the full life history of any one of the species is attended with much difficulty, and will require much time in field and laboratory; while the technical and classificatory treatment of the subject should be undertaken by some competent helminthologist.

C. V. R.

LETTER OF SUBMITTAL.

ARCHER, FLA., *December 2, 1888.*

SIR: I have the honor to submit the following report upon the root-knot disease and its cause, the *Anguillula*.

These investigations, conducted under your direction, began in February, 1888, and have been continued to this date.

While not conclusive in all respects, they are at least contributions to the history of this microscopic pest, that may eventually lead to its subjection or to the mitigation of its ravages.

In conclusion, allow me to express to you my thanks for your aid and guidance during the preparation of the report.

Respectfully submitted.

J. C. NEAL, M. D.,
Special Agent.

Prof. C. V. RILEY,
Entomologist.

THE ROOT-KNOT.

DEFINITION.

An abnormal and irregular growth of the subcortical layer of roots and subterranean stems, characterized by low vitality, the result of an invasion of the tissues by a Nematode worm. (Note 1.)

HISTORY.

Since the earliest settlement of the South Atlantic and Gulf States by white people this diseased condition of the roots of trees and plants has been recognized. (Note 2.)

A very slight inspection has shown the decaying enlargements of roots, but the cause has usually been attributed to a lack in the soil of some important fertilizing ingredient, or careless cultivation, rather than some potent exterior influence.

I have carefully examined all sources of information at my command, and can find no mention of the root-knot in any agricultural paper or book prior to the year 1857.

That year Hon. P. J. Berckmans established a nursery at Augusta, Ga., and soon found this disease prevalent in many varieties of trees and plants, and in 1881 Prof. C. V. Riley being at Augusta was shown the effect of the disease by Mr. Berckmans.

In 1869 Mr. Gilbert Onderdonk, of Nursery, Tex., noted the disease in his fig, grape, and peach stocks, especially in damp, undrained locations.

In 1876 I found the root-knot prevalent over Florida, and learned from old residents that as far back as 1805 it had been known, and from time immemorial had been dreaded as a foe to gardens and groves.

About 1874 this disease, however, sprang into prominence, owing to the influx of immigrants, the development of early-market gardens and the sudden rage for orchards of peaches, figs, and oranges.

Since that time the agricultural papers have contained numerous references to this disease. My own attention was called to this pest by repeated failures to grow certain plants in a rich, damp spot on my farm.

This led me to investigate; and sending a specimen of the knotty roots to the Agricultural Department at Washington, elicited the information that a microscopic worm was the cause of the trouble, but that little was known of the Nematoid family to which it belonged.

Beyond doubt, the disease is peculiar to the South Atlantic and Gulf coast within a limit of 150 miles from tide-water. (Note 3.)

Mr. P. J. Berekmans remarks on this score—and I know no better authority—“that it is indigenous to a large portion of the South seems undeniable, as I have seen it in places in Georgia and Alabama where neither trees nor plants had ever been introduced from other sections.”

Mr. Onderdonk also states a similar opinion. Other correspondents at Mobile, Ala., and in Texas confirm these statements.

PLANTS INVADED.

I.—Uncultivated :

a. Slightly affected :

Capsella bursa-pastoris (*Shepherd's Purse*).

Rubus villosus et trivialis (*Blackberry and Dewberry*).

Eupatorium fœniculaceum (*Southern Dog Fennel*).

Quamoclit vulgaris (*Cypress Vine*).

b. Badly affected :

Portulaca oleracea (*Purslane*).

Sesuvium pentandrum (*Sand Purslane*).

Verbesina siegesbeckia et sinuata.

Artemisia caudata (*Wormwood*).

Chenopodium botrys (*Jerusalem Oak*).

Amarantus spinosus (*Careless Weed*).

The above list, no doubt, will in time, and with a careful investigation, be greatly extended; most of these are the commonest of weeds in old fields and badly cultivated grounds, and the *Chenopodium* alone would be an ample shelter and breeding place for the *Anguillula*, independent of other wild or cultivated plants.

The *Eupatorium* and *Chenopodium* are perennials, spread rapidly, and have great vitality, and for years it has been noted that where these weeds abound the root-knot exists in the greatest degree.

The *Sesuvium* and *Portulaca*, both with fleshy roots, are very common, and are an easy prey to the worms, but my experience indicates the *Amarantus spinosus* as the most dreaded and destructive agent in the spread of the root-knot, its roots being apparently the favorite of the *Anguillula*.

In Georgia, my correspondents deem the *Verbesina* and *Artemisia* the weeds most diseased, but in Texas, Mississippi, and Alabama, the list is about the same as I have given for Florida. (Note 4.)

It will be seen that it will be impossible to determine certainly the original food-plant of this pest, as it seems to attack the roots of so many; and the inference that any tender growth not impregnated with a decided toxic principle may be invaded is a doubtful conclusion to my mind.

II.—Cultivated.

c. Useful.

a. Slightly affected.

Gossypium herbaceum et barbadense (*Cotton*).

Solanum tuberosum et esculentum (*Potato and Egg-plant*).

Capsicum annuum (*Pepper*).

Spinacia oleracea (*Spinach*).

Jatropha manihot (*Cassava*).

Zea mais (*Corn*).

b. Badly affected.

The Genus *Brassica* (*Sinapis*),
(*Cabbage, Kale, etc.*).

Raphanus sativus (*Radish*).

Hibiscus esculentus (*Okra*).

Pisum sativum (*Pea*).

Arachis hypogæa (*Pea-nut*).

Dolichos catiang (*Cow Pea*).

Phaseolus vulgaris (*Bean*).

Phaseolus lunatus et nanus
(*Bean*).

All of the Genus *Cucurbita*
(*Squashes, etc.*).

All of the Genus *Citrullus* (*Melon*).

All of the Genus *Cucumis* (*Cucumber*).

Lycopersicum esculentum (*Tomato*).

Beta vulgaris, varieties (*Beet*).

d. Ornamental.

a. Slightly affected.

Hibiscus syriacus et coccineus.

Mesembryanthemum, various species (*Ice-plant*).

Mikania scandens (*Parlor Ivy*).

Pharbitis purpurea et al. sp.
(*Morning Glory*).

Nolana, sp.

Petunia, sp. (*Petunia*).

Boussingaultia basseloides.

II.—Cultivated—Continued.

b. Badly affected.

Koniga maritima.

Iberis umbellata.

Lagenaria vulgaris (*Gourd*).

Begonia, sp. (*Begonia*).

Dahlia variabilis.

Helianthus annuus (*Sunflower*).

Coleus, var. sp.

Achyranthes, var. sp.

Amarantus var. sp.

Shrubs and Trees.

c. Useful.

a. Slightly affected.

Citrus vulgaris (*Bitter-sweet Orange*).

Citrus aurantium, var. sp. (*Orange, Lemon, etc.*).

Vitis, var. sp. (*Grape*).

Prunus myrobolanus (*Plum*).

Broussonettia papyrifera (*Paper Mulberry*).

Morus, var. sp. (*Mulberry*).

Juglans cinerea (*Walnut*).

Carya olivæformis (*Pecan*).

b. Badly affected.

Prunus domestica (*Plum*).

Prunus armeniaca (*Apricot*).

Prunus vulgaris (*Peach*).

Prunus communis (*Almond*).

Ficus carica (*Fig*).

Juglans regia (*English Walnut*).

Salix, var. sp. (*Willows*).

d. Ornamental.

Spiræa sorbifolia, var. sp. (*Spiræa*).

Prunus nana et lanceolata (*Flowering Almond*).

Buddleia, var. sp.

Gardenia florida (*Cape Jessamine*).

This long list embraces the greater part of our most valuable food-plants, fruit-trees, and many of the choicest flowers, and it fully justifies the inquiry now made as to the history and means to prevent the spread of the disease induced by the *Anguillula*.

I think it useless to endeavor to account for the apparent vagaries of the *Anguillula*, as, for instance, to ascertain why the roots of the *Prunus vulgaris* are so badly affected, while *Prunus cerasus* are unhurt; or why the *Leguminosæ* are susceptible and the *Umbelliferae* are not. It is reasonably sure that rapidly growing, soft-tissued roots are better subjects for invasion, expansion, and decay than those of slow growth and

denser structure, and the self-evident corollary is that methods and fertilizers promoting a rapid succulent growth should be avoided in all locations infected with the root-knot.

EFFECTS OF THE INVASION OF THE ANGUILLULA.

I have found mature worms, males and non-pregnant females, in rootlets but a few days old, and under circumstances which involved the necessity of invasion from without the root. See Experiment No. 22.

These Anguillulae were small enough to enter the "stomata" of epidermal tissues, active and strong enough to even penetrate cell-walls, or to separate cells in loosely connected tissues. Once within, they could easily pass through the Cienchymatous system of the Parenchyma to any portion of the root, and I think it not unreasonable to infer that in this manner they obtain entrance in young rootlets.

Their presence causes a rapid proliferation of cells, resulting in a soft, unnatural, irregular growth of the root, with low vitality, and a varied effect upon the plant or tree.

The Chenopodium, Eupatorium, Artemisia, Amarantus, Gossypium, Solanum, and Petunia have the enlargements usually on the sides of the main stem, near the surface. The "tap-root," descending deeply is rarely affected, and the plants seem slightly affected till the sub-cortical layer is filled with worms in all stages of growth. This checks growth, either by their absorption of the nutrition gathered by the rootlets, or obstruction of the Cienchymatous ducts, the food supply is cut off before decay is visible, the leaves wither, the stems shrivel, the plant dies. (Plate VIII, 1 a, 4 b.)

The roots of the Okra, Radish, Turnip, Cabbage, Cucumber, Melon, Cow-pea, Peanut, Tomato, and Egg Plant enlarge enormously, soon becoming little else than masses of decaying tissues. The plant stops growth, the fruit either becomes distorted or drops prematurely, the leaves change color and fall off, and the plants die so rapidly as to justify the usual expression "struck by lightning," applied to the fields of Melons, Cucumbers, Tomatoes, and Cow-peas so often badly affected by the root-knot. (Plates I, II, III, IV, and VIII.)

In nurseries of young fruit-trees the greatest mischief occurs. The soil is usually carefully prepared by heavy fertilizing and culture, and the seeds of the Peach, Orange, and English Walnut are sown for stocks. When the tender shoots first appear many wither and die at once, others grow vigorously till the end of the first season, when they are usually budded with known and valuable varieties of fruit. The next spring these buds put out tardily and make a weak growth, the leaves become spotted or yellow, then drop, the bud dies, feeble straggling shoots sprout around the stem, which maintain a sickly vitality till the first drought, when the tree dies, and an examination discloses the cause in the knotty, decaying roots, without rootlets or fibrillae.

With older trees taken from healthy locations and set in infected soil the program varies. The Peach and Fig often grow vigorously one or two years, and bear fruit that is very prone to drop immaturity, then the tree takes on an irregular growth of stunted limbs and small leaves. The tips of these limbs die back gradually to the body of the tree. If the soil is clayey the tree will put out feeble sprouts often for several years.

With the Pecan, English Walnut, and Willow, older trees remain stationary a year or so and die with the occasion of a severe drought.

In many cases, especially in old fields, the seeds of trees and plants barely germinate, or cuttings hardly form rootlets till they are invaded and destroyed.

In all of these cases the effect is to deprive the stems and leaves of food and moisture; the knots grow, the branches do not.

The annual destruction of nursery stock is enormous, especially the Peach, Fig, Willow, *Spiraea*, *Buddleia*, *Coleus*, etc.

In the sketches taken from nature, attached to this report, are shown typical specimens as far as possible.

The Grape, Fig, Mulberry, and Orange are prone to circular knob-like knots on the sides of the larger roots, and an occasional enlargement at the junction of small roots. (Plates IV and VII.)

The Peach, Plum, Walnut, and *Spiraea* grow irregular masses, involving the whole root seemingly. (Plate V.)

The Willow, Okra, etc., enlarge, and the decay is usually visible first at the extreme tip of growth from the central stem. (Plates VI, I, and II.)

TERRITORY OCCUPIED BY THIS DISEASE.

Early in the beginning of my studies of the *Anguillula*, I addressed letters of inquiry to most of the leading nurserymen and horticulturists in the United States, especially those in the southern section, asking an examination of diseased trees, and inclosing samples of the root-knot for comparison.

The replies I received are conclusive that the disease is unknown beyond any point in the interior 150 miles from the coast.

It does not exist except in locations free from extreme cold, and the northern boundary is not far from the January isotherm of 50°, as shown in the No. 2, Isothermal Lines of the U. S. Signal Service, 1881.

Letters from the Peach districts of Michigan, Maryland, and New Jersey complain of the "Yellows," but investigators do not report finding the diseased roots indicative of the *Anguillula*.

It is not found at Denison, Tex. (Munson), only along the coast in that State, and then only in sandy, wet locations. (Onderdonk.)

The usual dry air of New Mexico, California, and regions west of the Mississippi River, with the summer parched soil of these sections, forms apparently a barrier to the growth and spread of the disease, but coming

eastward it is progressively worse, till it reaches a climax in Florida, which seems to possess the requisite soil, humidity, and warmth for the proper environment of the *Anguillula*, and consequently its complete développement for mischief in gardens and groves.

Add to this the cultivation of special food plants extremely susceptible to invasion by the worm, and there can be no wonder at its prodigious increase.

TEMPERATURE.

The question of temperature is no doubt one of great importance in determining the boundaries of this disease, perhaps more so than food-plants or soils.

The soil that is annually frozen from 6 to 10 inches is nearly disinfecting from the worms, especially those existing in a free state in the soil, or inhabiting the soft roots of annual plants, and this may explain why southern Michigan, northeastern Ohio, and New Jersey, with as sandy a soil as Florida or south Georgia, still escape the plague in the Peach orchards.

The *Chenopodium*, *Artemisia*, etc., abound in these States, and no doubt are the habitat of *Anguillula*, but the continued cold reduces their number to the minimum each year, and the fibrous-rooted trees are unharmed.

Again, in some cold localities the trees kept in hot-houses are affected; those without in open ground escape.

Places favored with hot, dry summers and cold, wet winters will not likely ever suffer from the ravages of the root-knot.

My experiments are conclusive that below 50° in fluid, and above that, dry, the worms are inactive, paralyzed by cold, and shriveled by dryness and heat, and the inference is plain that parties wishing best results must either choose unsusceptible stocks, for grafting or budding trees liable to infection by the *Anguillula*, remove to favored locations, or find some means of destroying the worms.

The arid regions of the West fill one indication, the others are still *sub judice*, but in a fair way for determination.

SOILS.

It can not be questioned but that a light, sandy soil offers least resistance to the progress of the *Anguillula* after its liberation from decaying roots either encysted or free.

Experiments with air-dry soil show that water penetrates sand in half the time that it will penetrate clay, and over large areas of cultivated land the proportion would still be greater in favor of the sand.

Loose soils, mixed with decaying vegetation and humus, offer still better facilities for irrigation, and this explains the fact that locations highly fertilized with composts, stable manure, or leaf-mold show the root-knot quicker in plants than compact or virgin soils, and the worst

results are found in gardens planted in long cultivated, fully fertilized, and thoroughly pulverized areas.

Moisture is an essential to the vigorous growth of the *Anguillula*, though it withstands an enormous amount of drying.

The cysts shrivel, pregnant females become irregular in outline, mature worms stiffen and remain indefinitely with suspended vitality, but resume action with the application of sufficient moisture. (Note 5.)

A friable soil, with compact clay near the surface insuring needed dampness, presents then the typical environment for the *Anguillula*, and this, alas, also is regarded in this section as the most advantageous location for a garden or grove.

Another very favorable location for these worms is the boggy bank of a lake or river, where there is a mass of wet, decaying vegetation.

EXPERIMENTS.

A series of experiments, under the direction of the Entomologist of the United States Agricultural Department, was begun in February, 1888, to determine the migration and life history of the *Anguillula*, as well as to investigate the effect of various insecticides. That these are not complete and conclusive, is owing to the extreme difficulty of tracing any individual worm by reason of its size and its surroundings.

A quantity of both ordinary sandy soil and clay was heated several hours to a temperature of 400° F.

A number of 6-inch earthen pots were also subjected to the same heat. The earth and the pots were tested for living *Anguillulae* and found sterile.

- (1) Four sterile pots with $\frac{1}{10}$ cubic foot of sterile soil in each pot.
- (2) Same as No. 1, using sterile clay instead of surface soil.
- (3) As No. 1, using yellow subsoil from infected locations.
- (4) As No. 3, using clay subsoil from infected locations.
- (5) As No. 1, using infected surface soil from infected locations.

In each pot were planted four seeds of the Cow-pea (*Dolichos*), selected because of its ease in germinating and great susceptibility to the *Anguillula*.

All came up within the week and grew fairly well; at the end of each week one plant was removed and the roots examined.

In Nos. 1 and 2 no knots were visible at any stage of growth and the last plant grew to maturity.

In Nos. 3 and 4 the plants were but slightly affected, and at the end of the fourth week each remaining plant had made a fair growth, despite the terminal roots were becoming enlarged.

In No. 5 half the plants died before the appearance of the third leaf, and the remainder made a sickly, feeble growth. The roots were badly knotted, decay in every case appearing at the terminal ends of the rootlets, which turned brown and dropped off at the slightest touch.

I repeated this series of experiments, using small seedling peach trees in place of the cow-peas. The results were similar—the trees in Nos. 1

and 2 growing vigorously, with fully developed roots and leaves; in No. 3, at the end of four months the trees were living, but feebly, and the roots showed signs of decay.

In No. 4 the trees had grown somewhat better and had a brighter color, but the roots were knotty.

No. 5 showed poorly, leaves smaller, roots quite knotty, and one tree dead.

The same results followed using the Weeping Willow as the test plant.

The inferences are: That the *Anguillula* is destroyed by a heat of 212° ; that healthy trees set in infected soil soon are invaded by the free *Anguillula* in the soil; that soil taken from the depth of 2 or more feet below the surface is comparatively free from the worms, and that clay subsoil is less infected than the sand.

Another series of experiments testing the effect of various chemicals, fertilizers, and insecticides was tried, using four sterilized pots in each test, the pots each containing $\frac{1}{1000}$ cubic foot of infected sandy soil, and the chemical, at the rate of $\frac{1}{1000}$ of the weight of the soil (24 grains), thoroughly mixed or dissolved. In each pot was planted a seedling peach and four cow-peas.

No. 6. Tobacco dust.

7. Tobacco dust with 24 grains sulphate potash.
8. Tobacco dust with 24 grains sulphide potash.
9. Tobacco dust with 24 grains sulphite potash.
10. Tobacco dust with 24 grains muriate potash.
11. Tobacco dust with 24 grains hyposulphite soda.
12. Tobacco dust with 24 grains sulphate iron.
13. Tobacco dust with 24 grains caustic lime.
14. Tobacco dust with 24 grains unleached ashes.
15. Tobacco dust with 24 grains sulphur.
16. Bisulphide carbon.
17. Sulphate potash.
18. Muriate potash.
19. Unleached ashes.
20. Caustic lime.

These experiments were also repeated in the nursery and open field on small peach trees, using 602 grains to each tree, equivalent to $\frac{1}{1000}$ part by weight of the soil. (Note 6.)

In the pots the results in Nos. 6, 7, 10, 13, and 14 were very encouraging; the peas grew to maturity, with good color and very few enlarged roots. Nos. 8, 9, 11, and 15 made a very poor growth, and died soon after the third leaf. No. 12 died immediately after sprouting, as did No. 16. Nos. 17, 18, and 19 grew nearly as well as Nos. 6 and 7; No. 20 made a fine growth, with very few enlarged roots. The peach trees died soon in Nos. 8, 9, 11, 12, 15, and 16, made a fair growth in Nos. 6, 7, 10, 13, and 14, were killed at once in No. 16, and grew the best in Nos. 17, 18, 19, and 20.

In the field Nos. 11, 16, and 8 appeared to at once kill the trees. Nos.

9 and 15 had no effect visible. Nos. 6, 7, 10, and 14 made a better growth than Nos. 17-20. Root-knot was present on all but Nos. 13, 14, and 20.

On still larger trees, applied at the rate of 27 pounds to the tree, Nos. 6, 13, 14, 17, 18, 19, and 20 gave good results, especially 6 and 17, 6 and 18, 6 and 19. These mixtures seemed to promote a vigorous growth of healthy roots, and Nos. 6 and 20, each 27 pounds to the tree, well mixed with the surface soil, appears to be as near a preventive of the "knot" as anything I have tried.

I tried the bisulphide of carbon without any effect other than the death of the trees, some fifty or more, and the kerosene emulsion to saturation of the surface soil produced a similar result, and in view of the expense and labor involved I did not repeat the experiment. (Note 7.)

A number of the prepared artificial fertilizers were tried; those containing ammonia, guano, bone, and fish produced a rapid growth, soft and easily attacked by the *Anguillulæ*.

In a field near my place, heavily fertilized with a bone and potash compound, the roots of the pea-nut became masses of knotty roots, the worst cases of the disease I ever saw, and peach-trees growing in that field are ruined.

I have found nothing of value when applied to old bearing fruit trees, if badly affected, as any insecticide capable of absorption by the roots invariably has killed the trees when used to the amount of $\frac{1}{100}$ the weight of the surface soil, 1 foot in depth and the area of the circle filled by the roots. Alkaline mixtures, 20 to 40 pounds to each tree, or caustic lime, kainite, muriate and sulphate potash or wood ashes, used several years in succession, have come nearest a cure, destroying no doubt many free worms, and inducing a vigorous, tough growth of roots, more difficult of penetration, and possibly rendering the sap in some way obnoxious. (Note 8.)

The addition of tobacco dust in large quantities supplies nitrogen, and makes a very vigorous growth of roots and limbs. It also seems to have considerable preventive effect on the worms. Experiments conducted by one of our market gardeners has convinced him that the mixture of tobacco dust and muriate of potash in old fields in great measure prevents the ravages of the *Anguillula* in Okra, Cabbage, and Egg-plant, and he has adopted this as a standard fertilizer for all his products. I have seen his use of this, and am nearly prepared to sustain his views. Kainite is no doubt fully as good, but further experimenting is necessary.

Another series of experiments was made upon plants to determine the time and degree of infection.

No. 21. Sterilized pots with $\frac{3}{100}$ cubic foot of sterile soil, in which four cow-peas were planted at various depths, one-half inch, three-fourths inch, and 1 inch, were covered 1 inch with infected earth and kept watered. The results showed infection of the roots in about the same ra-

tion as the distance from the surface. Reversing the process, putting the infected soil below, showed the roots affected soonest in the peas planted deepest, indicating but little action in the worms outside of that produced by the percolation of water.

No. 22. Another series of pots were watered with muddy water from infected earth, and though the pots contained sterilized soil the roots of the peas were badly affected. Microscopic investigation of the percolate showed both free and encysted *Anguillule*. (Note 9.)

No. 23. Pots with sterile soil had one transplanted infected peach seedling in each, and four cow-peas.

The trees soon died, and very shortly afterward the peas showed the infection, those nearest the dead peach roots the most markedly.

In a spot of new and non-infected ground several trees, Peach and Fig, were planted. The central tree was knotty-rooted and died in a few months; the next year the roots of the nearest trees, 15 feet away, became knotty nearest the dead tree, and now, after the lapse of four years, the disease extends to the tips of the roots of all the Fig and Peach trees in a circle 120 feet distant each way from the original infected tree.

In another case, in a nursery on high pine land, clay subsoil and free from disease, a number of peach roots, badly knotted, were brought from a distance and heeled in for a week. The disease spread in all directions from this nucleus.

Again, in another peach nursery was a spot of low, damp, black soil. There was no root-knot the first year it was planted in peaches; the seedlings grew well. The second year, a few trees were found in this spot with enlarged roots and destroyed. The third year, hardly a tree escaped, the disease extending along the thickly set rows of seedlings upward and in all directions on to the higher land from the hollow spot first infected.

In another case, clean fibrous-rooted trees were heeled in a day or so and planted in non-infected ground. The next year proved the most of them diseased.

These cases prove conclusively that in areas not infected the disease can be easily introduced (1) by planting infected trees; (2) by the use of composts of muck and weeds from infected soils; (3) by the distributive action of water and air, the water carrying particles of soil and worms downward from an infected elevation, or by dry soil, fragments of dry roots, desiccated free or encysted worms carried in the air during sand-storms, whirlwinds, or the heavy currents of air preceding storms that often blow "bare" acres of plowed land and overwhelm adjacent fields with the soil thus borne on the wind; (4) soil containing these worms I have no doubt has been carried on the feet of men and animals and deposited in healthy fields, forming the nucleus of a destructive agency, months afterward made visible by its effects.

Instances are not wanting that can not be explained except by some such theory of contagion and manner of travel.

REMEDIES.

1. DRAINAGE.

Many gardens and orchards are badly located on soils partly saturated with water, either at the margins of rivers or lakes or on rich deposits of vegetable remains both low and damp.

The reasons for this choice are generally the superior quality of the land and the rapidity of growth induced by the moisture, but in the territory infected by the *Anguillula* the heat and rich soil cause precisely the looseness of tissue so favorable to the spread of the worms.

A dry soil, with solid root-growth, is on the contrary unfavorable; hence in many locations drainage has entirely changed the character of the land, so that peaches and figs grow where they would not before.

Experiments in Texas confirm this fully and suggest the utility of thorough drainage of wet locations, or, better yet, the avoidance of such places for groves and gardens.

In this connection it may be remarked as one of the not expected results of the "New Agriculture" in maintaining a permanently damp soil by means of water-pipes below the surface, that when it is in vogue we will have not only a great increase of crops but a greater increase of "root-knot" in the cabbages, beets, radishes, etc., thus grown. What effect the ingestion of *Anguillula* will have upon the human economy remains to be seen; as, so far as I know, no record occurs of experiments having been tried to ascertain. (Note 10.)

2. FROST.

In many places north of 29° there is cold enough each year to at times freeze the surface a considerable depth. Where this occurs, by plowing the soil at the beginning of winter and at times during that season, it is reasonable to suppose great destruction of the free *Anguillula* will ensue.

3. FIRE.

The value of heat in the destruction of the germs of the root-knot has been often demonstrated in Florida, usually unwittingly, and the lesson taught has been in a measure lost.

In clearing old fields, badly infected with the worms, as shown by the crops of cotton or peas, it is customary to burn log-heaps and stumps; if, then, peaches and figs have been planted on this burned land the result has been freedom from root-knot for a series of years.

Such trees make a vigorous growth and bear well, while adjacent trees, not on burned ground, wither and die.

It would seem practicable in this wooded section to easily build small compact heaps of chips, wood, pine knots, even dry weeds and grass, over the area of say 2 feet radius from each tree-stake prior to plant-

ing, burn the heap to ashes, excavate the soil as far as heated, and renew the fire till the subsoil is reached and the depth of at least a foot of soil in all is thoroughly sterilized by heat.

In many cases, where wood is plenty, dead standing timber to be removed, and stumps to be burned, the plan would succeed to stake out the field and build a log-heap at each stake; but if not convenient, the annual growth of weeds and grasses, well dried, will furnish fuel enough.

4. STERILE SOILS. (Note 11.)

Among the early settlers of Florida the practice prevailed, when planting trees, of digging out the soil to the depth of 2 or more feet and filling in around the tree with clay or yellow subsoil obtained from virgin land and 3 or more feet below the surface. This plan succeeded, in that it surrounded the tree with sterile soil till it formed firm roots and a hardened epidermis.

My investigations show that in infected soils the deep roots are but slightly affected in comparison with those near the surface, and that the greatest destruction prevails in young trees, nursery stock, and plants having surface roots.

If a tree acquires age and the roots reach deep subsoil, the *Anguillula* do little damage. Hence the utility of using clay or subsoil, derived from virgin forest, around newly-set trees.

This old plan deserves attention and can be recommended; but since the war, in their haste to promote the growth of groves and gardens, the later horticulturists reverse this method, imbed the young tree in surface soil, and use nitrogenous fertilizers to encourage rapid development, this certainly causes increase of the root-knot.

5. DISUSE OF LAND.

Keeping land clean, free from all growth for two or more years, has proved of great benefit if done before trees are planted. I believe the worms require living tissues to develop in, and deprived of this they would die, probably within the limit I have given.

In many places where the soil has not been cultivated for a long series of years, and the Broom Sedge Grass has exterminated all other weeds, I have failed to find any traces of the *Anguillula*, and I regard this as confirmatory proof that disuse of land prevents the root-knot.

6. DISUSE OF EASILY INFECTED CROPS.

In most of our Southern States, where the Clovers and Buckwheat will not prosper, it has been the almost universal custom to substitute the Cow-pea as a soil-renovator. Drilled or broadcast it is the great crop for "laying by" corn, and as a second or third crop after rice, oats, or market garden. Very few groves or orchards but have annually from one to three crops of pea-vines plowed in for fertilizing.

Again, as a "first crop," after clearing off the timber, it is in general use for new land. Few plants are so sensitive to the attacks of the *Anguillula*, and few have roots so badly infected with these worms, and this common custom of planting the Cow-pea is mentioned only to be condemned, as, if continued, in time all groves and gardens in these sandy soils will be failures.

The *Lespedeza striata* (Japan Clover), *Desmodium molle* (Beggar Weed), and *Richardsonia scabra* (Mexican Clover), will prove fine substitutes for the Cow-pea as forage and fertilizer. If the Cow-pea must be grown, keep it away from garden and orchard, and at planting time use large quantities of some strong alkaline fertilizer on the soil. The economical habit of planting market gardens in orchards should be discouraged.

It is easy to see the reason and the danger from the use of ammoniacal fertilizers so necessary to induce rapid growth of vegetables, and the spread of the *Anguillula* from the roots of the Melons, Cucumbers, etc., to the trees. Many instances of this sort can be seen over the South, and should serve as warning to our horticulturists in the future.

I believe that in badly infected grounds some relief could be given by drilling the Cow-pea, and, when in bloom, cutting off the stems for forage; then to plow and carefully rake up the roots in piles for burning when dry enough. This method of destroying the infected roots of Okra, Melons, etc., and the roots of the *Obenopodium*, etc., would no doubt be of great value in small areas, and even in larger fields, by the aid of improved machinery for gathering the roots.

It needs only the mention that planting of trees from infected localities should be avoided; even those not liable to the disease themselves may carry soil containing *Anguillulae* among the roots.

I have noted that the Peach and Fig obtained from Northern nurseries seem extremely easy to take the disease, far more so than the native stocks. I only mention the fact, but have not ascertained the reason.

7. INSECT ENEMIES.

I have found but one, the small blackish-brown ant that inhabits rotten wood and decaying roots—very common in this section—the *Solenopsis xyloni*.

This, when the roots of the Okra, Pea, etc., begin to decay, burrows into the tissues and drags out the pregnant *Anguillulae* for destruction.

I was puzzled at first to find the dead roots of the Okra, Melon, Peach, and Fig free from cysts or pregnant worms, though in partially rotting enlargements I found plenty of *Anguillula*.

Closer and extended examination showed this ant in the act of devouring the enlarged worms, and its service to the orchardist is beyond value in this respect.

Inasmuch as a dry soil is favorable to ant life, it will be readily seen how drainage is useful in aiding the propagation of this tiny destroyer.

Upon crushing a mature, pregnant worm various forms of micrococci are visible by the microscope as existing within the *Anguillula*, evidently not hurtful, and when seen exterior to the worm seem not prejudicial to its life; but more study is needed on this point.

8. USE OF VERMICIDE FERTILIZERS.

Experiments looking to the adoption of some mixtures capable of destroying the worms while in the root tissues have not proved a success. The use of smaller quantities per acre than one-tenth of 1 per cent. of the surface soil for 1 foot in depth and 10 feet radius to each tree—about a ton to the acre—produced no perceptible effect on the disease, and a greater amount injured the trees.

The use of bisulphide carbon, kerosene emulsion, and various arsenical solutions destroyed so great a percentage of the trees that on that account, and the expense of application, it was abandoned.

Alkaline mixtures have done better, and will bear repetition, especially the sulphites and muriates.

For nursery stock, it no doubt will pay to thoroughly incorporate some of these chemicals with the soil some weeks before planting seeds, cions, or young trees, using it at the rate of at least one-tenth of 1 per cent. of the surface soil cultivated.

Alkaline fertilizers, as hard-wood ashes, muriate and sulphate of potash, kainite, or ash element produce a hard growth but little, if any, affected by the root-knot. Usually the fertilizer is applied in too small a quantity. Not less than 3,000 pounds to the acre should be used to produce the required effect, one-half in December, the remainder in May.

A fertilizer containing a small percentage of carbolic acid, carbolates, thymol-cresol, or an easily decomposed sulphite would no doubt be valuable in this infected section.

9. NON-INFECTED STOCKS.

After all, I believe the use of trees that are not susceptible to the root-knot, for stocks on which to graft or bud the susceptible varieties is the proper solution of the root-knot problem. The matter of location, soil, fertilizer, and prevention then need not worry the intending orchardist. Find the disease-proof tree and the thing is done, and most of my experiments have been directed to secure in some measure this result.

It is, perhaps, too soon to say that complete success has been realized, but the gain is perceptible.

For the Orange I can recommend the hardy bitter-sweet or sour species as nearly disease-proof and a vigorous grower.

The *Citrus trifoliata* and the Japanese "Unshiu," or Satsuma, both seem resistant, but the time of trial has been too short. This last is a slow grower, with dense roots, and promises to be the best of any of the

Citrus family. Its hardiness, freedom from thorns, and vigor recommend it.

Grapes of the *Vinifera* type as well as those of the *Æstivalis* group are subject to the root-knot, if grown on their own roots, but grafted into stocks of the *Cordifolia* or *Vulpina* races have made superb growths free of the disease.

I have found no stock for Fig or Mulberry that has stood the test.

For the Peach family either the seedlings of the Wild Goose Plum, the Marianna, or the recently introduced Japanese Plums, Kelsey, Satsuma, or Ogru, are valuable. Three years' test of the Marianna prove that for that time, at least, the roots resisted the *Anguillula* and were free from knots. When the peach died the *Myrobolan* was infected slightly, and even the native plums suffered with the disease. It is too soon to give an unqualified approval of this as a stock, but so far it is the very best, growing from cuttings and very rapidly, making a tree that is nearly borer-proof as well as free from the *Anguillula*.

Some seedlings of our American Plums are destined to replace the Peach as a stock, unless the Japanese varieties prove superior.

I have found nothing of value for the English Walnut as a stock, nor for the Weeping Willow.

I have indicated the probable line of action to mitigate or prevent the disease in gardens—the use of alkaline fertilizers, the exposure to frost, the gathering of diseased roots to burn, the removal of certain weeds, and the disuse of land and cow peas.

EXTENT OF DESTRUCTIVE EFFECTS OF THE DISEASE.

Within the district infected by the *Anguillula* it would be well nigh an impossibility to give even an approximate idea of the losses sustained each year by the farmer, the gardener, and the horticulturist from the ravages of this worm.

All over the southern section of the United States hundreds of market gardens have been planted at an immense outlay of time and money, only to have the fields of vegetables blighted from this mysterious trouble, as if scorched by fire or frost. Thousands of trees have been planted only to dwindle away and die; and, as the defect has been usually ascribed to the fertilizer or the climate, the injury has been enormous, while the real cause has not been suspected, and, as far as I know, no effort made to ascertain a remedy. The Orange is slightly affected now, but in the future, when the soil will be filled with cysts and worms, Orange trees will be as uncertain, I fear, as the Peach or Fig at the present time.

From the best testimony I can get, in the early days of the white immigration, except in damp locations, peaches grew without any disease, save the "Borer." Now, in many places, the trees that do well are the exception, and in these locations it is idle waste of time, labor, trees, and fertilizers to attempt the culture of an orchard.

In such infected spots the usual program is to apply some costly

ammoniacal manure to the land, cultivate early vegetables between the trees; then, after that crop is removed, sow the land in cow-peas. The result is bewildering. Next year the unfortunate planter is discouraged to find many of the trees dying back, the vegetable crop with knotty roots and irregular fruit.

Another heavy fertilizing, another crop of peas, and that spot is done for. The disgusted farmer tries another vocation, and gives over the place to weeds and desolation.

With young, closely-set rows of trees the disease causes greatest damage, spreading rapidly from tree to tree.

In market gardens, especially the Tomato, Cucumber, Melon, and Squash, the *Anguillula* often either destroys the plants before fruiting or reduces the size of the fruit till it fails to pay expenses.

A number of disastrous failures with gardens, that have come to my notice, no doubt resulted from this cause.

LIFE HISTORY OF THE ANGUILLULA.

The study of this microscopic worm has been exceedingly difficult, and many points in its history are not yet fully ascertained.

The limit of its existence, periods of growth, sexual characteristics, generation, variation of form, and the precise action occasioning the abnormal growth in roots, are all undetermined questions which will take a long continued series of observations to solve. (Note 12.)

As first observed, a mass of cells appears within the uterine cornua, cells averaging $\frac{1}{20000}$ inch in diameter, arranged in bands from $\frac{5}{10000}$ to $\frac{1}{10000}$ inch in width, reaching across to the walls of the uterus. (Plate XX, A, B.) These bands appear at the smaller end of the uterus, beginning from $\frac{2}{10000}$ to $\frac{3}{10000}$ inch from the free extremities, extending downward $\frac{3}{10000}$ to $\frac{6}{10000}$ inch. Lower down, these cells show a tendency to aggregate into irregular masses (Plate XX, B, C), then into ovate forms, eventually becoming ovals $\frac{5}{10000}$ by $\frac{1}{10000}$ inch.

At first these cysts have no epidermis, but a thin coating appears and thickens as they approach the normal size of $\frac{3}{10000}$ inch in length and $\frac{1}{10000}$ inch in width. (Plate XX, D, 2.)

During the life of the female the cysts form rapidly, until the whole uterus becomes enormously enlarged, and contains cysts in every stage, from the primary agglomeration of cells to free *Anguillulae*. (Plates XIX and XVIII.)

The decay of the environing root exposes the pregnant female to changes in weather, and with a slight increase in heat the contraction of the exterior expels the contents of the uterus and disperses them.

This in most cases appears to be through the upper segment, though often it occurs through the fissure in the head. (Plate XIX.)

The cyst at first is a solid mass of granular cells. (Plates IX, 1, and X, 1.) It divides centrally at the shorter axis (Plates IX, 2, 3; X, 2, 26, 4); each half repeats this process till four or five segments are visible.

A longitudinal fissure then appears, causing eight segments (Plates

IX, 6, 7; and X, 15, 16, 18); the walls of the segments are absorbed each side the central long fissure (Plate IX, 8, 10, 15, 16, 17, 18), which extends to the margin of the cyst in one direction, and upon separation at that end motion begins, and the *Anguillula* awakes to life and action. (Plates IX, 17, 18; and XI, 1.)

The growth within the cyst continues till the worm attains a length of $\frac{1.50}{10000}$ inch or more, and a central diameter of $\frac{1.50}{10000}$ inch; the cyst ruptures, the worm is free (Plate XI, 2, 3, 7), leaving the empty shell shrunken and torn. (Plate XI, 4, 4a.)

Up to this point I have failed to discriminate the sexes. Both appear blunt at one end, which is marked with a fissure $\frac{1.00}{10000}$ inch to $\frac{1.00}{10000}$ inch in length, often with a circular hinge-like termination (Plate XII, 3a, 4a, 6a, 7a, and XIII, 1a, 2a, 3a) extending into a tortuous channel $\frac{1.00}{10000}$ inch in diameter and averaging $\frac{1.00}{10000}$ inch in length; then the remainder of the worm becomes a mass of cells of various sizes to within $\frac{3.0}{10000}$ inch or $\frac{5.0}{10000}$ inch of the extremity or tail.

These cells at times appear with a sinuous channel clear from either end (Plate XII, 4), or with breaks in their continuity (Plate XII, 2, 3), or granular masses interspersed (Plates XII, 6, 7, and XIV, 1, 2), or as fine cells irregularly arranged. (Plate XIII, 1, 2, 3.) Occasionally the whole interior appears as a solid mass of cells. (Plate XII, 6.)

I have not discovered the method of impregnation, but at an early period rapid changes in shape begin in the female. (Plates XVI, 2 to 15; XVII, 1 to 9; XIV; XV; and XII, 5, 6, 7, 8.) The enlargement is preceded by the formation in both upper and lower thirds of the body of dark masses of cells that eventually unite (Plates XIV, 3, A, B; 4, 5, A, B, C, and 6; XV, 2, 3), then by the time the worm reaches the age represented in Plate XVI, 11, 12; Plate XVI, 3, 4, become changed into a bicornate ovarium or uterus, which at full term attains the length of $\frac{2.00}{10000}$ inch in many coils, and contains one hundred and fifty or one hundred and sixty full-sized cysts.

The shapes and sizes of these pregnant females vary greatly, and I believe are the result of the environment. In soft tissues of the Cow-pea, Radish, and the like rapidly-growing plants they attain a transverse diameter of $\frac{3.00}{10000}$ inch, and a length of $\frac{1.00}{10000}$ inch. The tail is reduced to a short spine (Plates XIV, 3; and XV, 2, 3), which disappears later on, as the worm approaches the transverse diameter of $\frac{1.50}{10000}$ inch. (Plate XVII, 3, 4.)

The thickness of the exterior wall varies from $\frac{1.00}{10000}$ inch at the lower part of the body to $\frac{1.00}{10000}$ inch at the vertex, and is exceedingly tough and resistant. In color it appears yellowish by transmitted light, but a brilliant white by reflected light. When fully developed, it is partly transparent, showing the coils of the uterus with its cysts. The exterior is granular or corrugated, especially near the "head" (Plates XIV, 6, and XIX), and with an apparently radiate arrangement of cells from a center near the tail, or perhaps marking the disappearance of that appendage. (Plate XXI.)

The head varies from a form like Plates XVII, 3, 4, 7, 9, and XVI, 9, 12, 13, 14, to that shown by Plates XVI, 10, 11, 15; XVII, 2, 5, 8, and XVIII, the neck from a mere contraction of the body, Plates XVII, 6, and XVI, 15, to a long tube, as in Plates XVI, 14, and XVII, 9.

The body varies from almost a globe (Plate XVI, 9, 13) to an oval (Plate XVI, 14; XVII, 9), or nearly a cylinder. (Plate XVI, 15.)

The worms found in woody tissue are usually of the forms of Plates XVI, 10, 11, and XVII, 5, 8; in soft tissues like Plates XVI, 14, and XVII, 7, 9, but I am unable to understand the reason of this variation.

In roots, as a rule, the bodies radiate from the central axis of the root with the "heads" to the axis.

When once enlargement of the body begins, the worm becomes a fixture, and remains incapable of progression in any direction; the enlargement is gradual and the cells of the root tissues become smaller by the pressure, forming a rigid wall on every side of the worm.

How long the worm exists is an unsolved problem which I hope to solve in time.

Apart from vegetable tissues, I have noted signs of life in the *Anguillula* after being kept air-dry six months, but have no record of any reliable experiments with the worms in the roots; but the vitality is very great.

When motion is first perceived in the cyst, the worm is an average of $\frac{1}{10000}$ inch in length and $\frac{5}{10000}$ extreme thickness; soon after it becomes free it enlarges and lengthens till it casts its skin, which it does as shown in Plate XI, 5, leaving the old skin shrunk as at 6, same plate; a fragmentary cast is seen on Plate XII, 1, but I have not determined the number of times in its life it sheds the skin, as it is rare to find a perfect cast for measurement.

Among the thousands of *Anguillulae* I have examined, there are a great many variations and arrangements of cells that are not easily explainable. Plates XV, XIII, and XII, 5, 8, 7, 6, exemplify some of the most marked. Plate XIII, 2, 3, is very singular; a cyst-like form, with segments. Also at 3, a peculiar arrangement of cells, large and small; in fact, I have never found two worms exactly similar in the grouping of cells; the resemblance is general, but with wide variation of details. The examples given in the plates justify this conclusion, sketched as they were from living specimens.

The arrangement of the cysts in the uterus is generally as shown by Plates XVIII, XIX, and XX, though that often becomes changed, as indicated in Plate XXI. (Note 13.)

In mature and apparently aged worms, I have found as many as a dozen free worms within the uterus, having attained motion and liberation there.

In plates showing the changes in vegetable tissues, "A" refers to the enlargements and nests of *Anguillulae*, "B" to spots of decay.

NOTES.

NOTE 1.—Owing to a lack of literature on the subject, I have provisionally named this worm *Anguillula arenaria*, but it may belong to a different genus. If an *Anguillula*, it is very near the *A. brevispinosus*, but as the spine disappears in mature forms, I have called this *A. arenaria*.

NOTE 2.—This information came from one of the oldest citizens, who learned of it from the Spanish residents in 1820.

NOTE 3.—Letters received from correspondents at nearly every important town gave the data.

NOTE 4.—Messrs. Berckmans, Onderdonk, Munson, and Stelle are referred to.

NOTE 5.—I kept fully developed pregnant females in a watch glass dry for six months, and when wet, they expanded, and the grown worms within the cysts in the uterus resumed motion.

NOTE 6.—The average weight of a cubic foot of ordinary sandy surface soil is 6,602,625 grains, equal to 86.08 pounds avoirdupois; this at the temperature of 70°, the soil being air-dry.

NOTE 7.—The quantity required to saturate a cubic foot was 2.3 gallons of the kerosene emulsion.

NOTE 8.—The amount of lime used was 20 pounds to the tree, forty-nine trees to the acre.

NOTE 9.—Water poured upon the pots percolated through the soil and out at the hole in the bottom of the pot. This was allowed to evaporate considerably and examined with magnifier 350 diameters, eye-piece B, objective one-half inch.

NOTE 10.—Radishes and turnips are very susceptible to the *Anguillula*. (See Plate III, drawn from actual specimen, natural size.)

NOTE 11.—A common practice among the "old-time" slaves, who tell me it was the rule made by the old whites as far back as 1805. The reason they gave was "the peach loves clay and yellow sand."

NOTE 12.—I could only approximate the growth and development by the use of such plants as the Cow-pea and Radish—planting seed in infected soil, and at certain dates pulling up the plants and examining the knots, making a careful sketch, drawn to scale, each time. All attempts at cultivating in fluids failed.

NOTE 13.—By softening the exterior with a solution of caustic potash, snipping off the head and gently pressing the body in fluid, with a cover glass, the uterus exuded as shown in Plate XIX.

EXPLANATIONS TO PLATES.

PLATE I.

Roots of Cow Pea, showing enlargements caused by *Anguillula*: A, enlargement and nests; B, spots of decay. (Original.)

PLATE II.

Roots of Okra, showing enlargements caused by *Anguillula*: A, enlargements and nests; B, spots of decay. (Original.)

PLATE III.

Roots of Radish, showing enlargements caused by *Anguillula*: A, enlargements and nests; B, spots of decay. (Original.)

PLATE IV.

Roots of Grape [Black Hamburg], showing enlargements caused by *Anguillula*: A, enlargements and nests; B, spots of decay. (Original.)

PLATE V.

Roots of Peach, showing enlargements caused by *Anguillula*. (Original.)

PLATE VI.

Roots of Weeping Willow, showing enlargements caused by *Anguillula*—natural size. (Original.)

PLATE VII.

Roots of Fig, showing enlargements caused by *Anguillula*—natural size. (Original.)

PLATE VIII.

1, section of root of Okra, showing enlargements caused by *Anguillula*; 2, Peach, same; 3, Grape, same—enlarged four times; 4, Weeping Willow, same—natural size: A, enlargements and nests; B, spots of decay. (Original.)

PLATE IX.

Reproductive cysts which form in the uterus of the female *Anguillula*: 1, first stage, solid mass of granular cells; 2, 3, segmentation or division into two parts; 4, 26, 5, 5a, 6, segmentation into four parts; 7, longitudinal fissure appearing, which causes segmentation into eight parts; 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, walls of segments absorbing each side of the central longitudinal fissure which extends to the margin of the cyst in one direction, until upon separation at that end motion begins—greatly enlarged. (Original.)

PLATE X.

Reproductive cysts (continued): 1, 1a, first stage; 2, 3, 4, 26, bi-segmentation or division into two parts; 5, 6, 7, 8, 9, segmentation into four parts; 10, 11, 12, 13, 14, 15, 16, 17, 18, segmentation into eight parts—greatly enlarged. (Original.)

PLATE XI.

Developed or free Anguillulæ within the reproductive cysts: 1, free Anguillula within cyst not yet broken; 2, 3, 7, cyst broken; 4, 4a, empty shell of cyst from which Anguillulæ have emerged; 5, young worm casting skin; 6, empty skin cast by young worm—greatly enlarged. (Original.)

PLATE XII.

Growth of Anguillulæ: 1, cast skin of young worm; 2, 3, 4, 5, 6, 7, 8, worms showing bluntness at one end, with fissure having a circular, hinge like termination at A, and granular masses of cells within—greatly enlarged. (Original.)

PLATE XIII.

Growth of Anguillulæ (continued): 1, 2, 3, worms showing masses of fine cells irregularly arranged within, and fissure at blunt end with circular, hinge-like termination at A—greatly enlarged. (Original.)

PLATE XIV.

Growth of Anguillulæ and changes within the female: 1, 2, female worms showing granular masses within; 3, 4, 5, 6, changes in shape in the female, preceded by formation in upper and lower thirds of body of dark masses of cells, A, B, C, which eventually unite—greatly enlarged. (Original.)

PLATE XV.

Changes within female Anguillulæ (continued): 1, 2, 3, enlargements in shape of the female, with formation of masses of cells at A—greatly enlarged. (Original.)

PLATE XVI.

Changes in form of female Anguillulæ: 1-15, outlines showing changes in form, from leaving the reproductive cyst until the female is herself filled with cysts, also showing changes in the form of the head and disappearance of the tail—greatly enlarged. (Original.)

PLATE XVII.

Changes in form of female Anguillulæ (continued): 1-9, outlines of changes in form of body and head, with the disappearance of the tail—greatly enlarged. (Original.)

PLATE XVIII.

Gravid female Anguillula, showing contracted head and neck as in some females, and the arrangement of cysts in the uterus—greatly enlarged. (Original.)

PLATE XIX.

Arrangement of cysts in uterus of female Anguillula and expulsion of young worms through fissure in the head—greatly enlarged. (Original.)

PLATE XX.

Arrangement of cysts in uterus of female *Anguillula* (continued): A-B, cysts arranged in bands reaching across to the walls of the uterus; B-C, aggregation of cells into irregular masses within the uterus; C-D, aggregations of cells arranged in two rows in the uterus; D-E, cysts that have attained the normal size and become coated with a thin epidermis—greatly enlarged. (Original.)

PLATE XXI.

A changed arrangement of cysts within the uterus of the female *Anguillula* which often occurs—greatly enlarged. (Original.)

PLATE I.



COW PEA.

PLATE II.



OKRA.

PLATE III.



RADISH.



PLATE IV.



GRAPE.

Vitis Vinifera — Black Hamburg.

PLATE V.



PEACH.

PLATE VI



WEeping WILLOW.

Natural size.

PLATE VII.



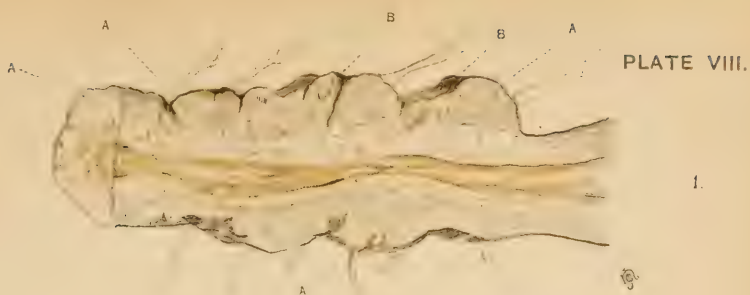
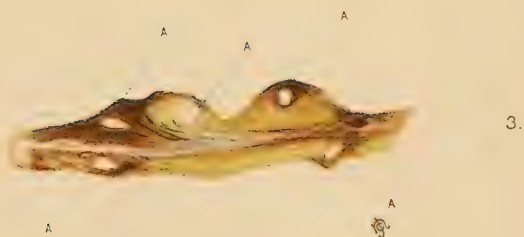


PLATE VIII.

OKRA. Section X 4.



PEACH. Section X 4.



GRAPE. Section X 4.



WEeping WILLOW.

Natural size.

PLATE IX.



1



2



3



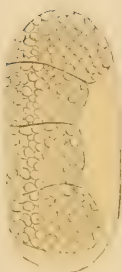
4



4a



5



5a



6

10
300



7



8



9



10



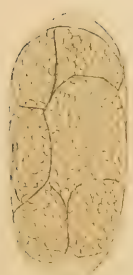
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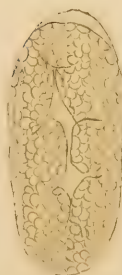
12



13



14



15



16



17



18

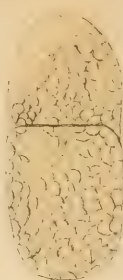
PLATE X.



1.



1 a.



2.



3.



4.



26.



5.



6.



7.



8.



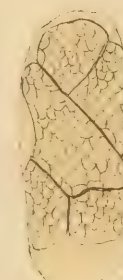
9.



10.



11.



12.



13.



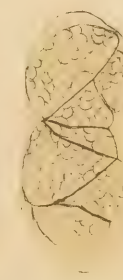
14.



15.



16.

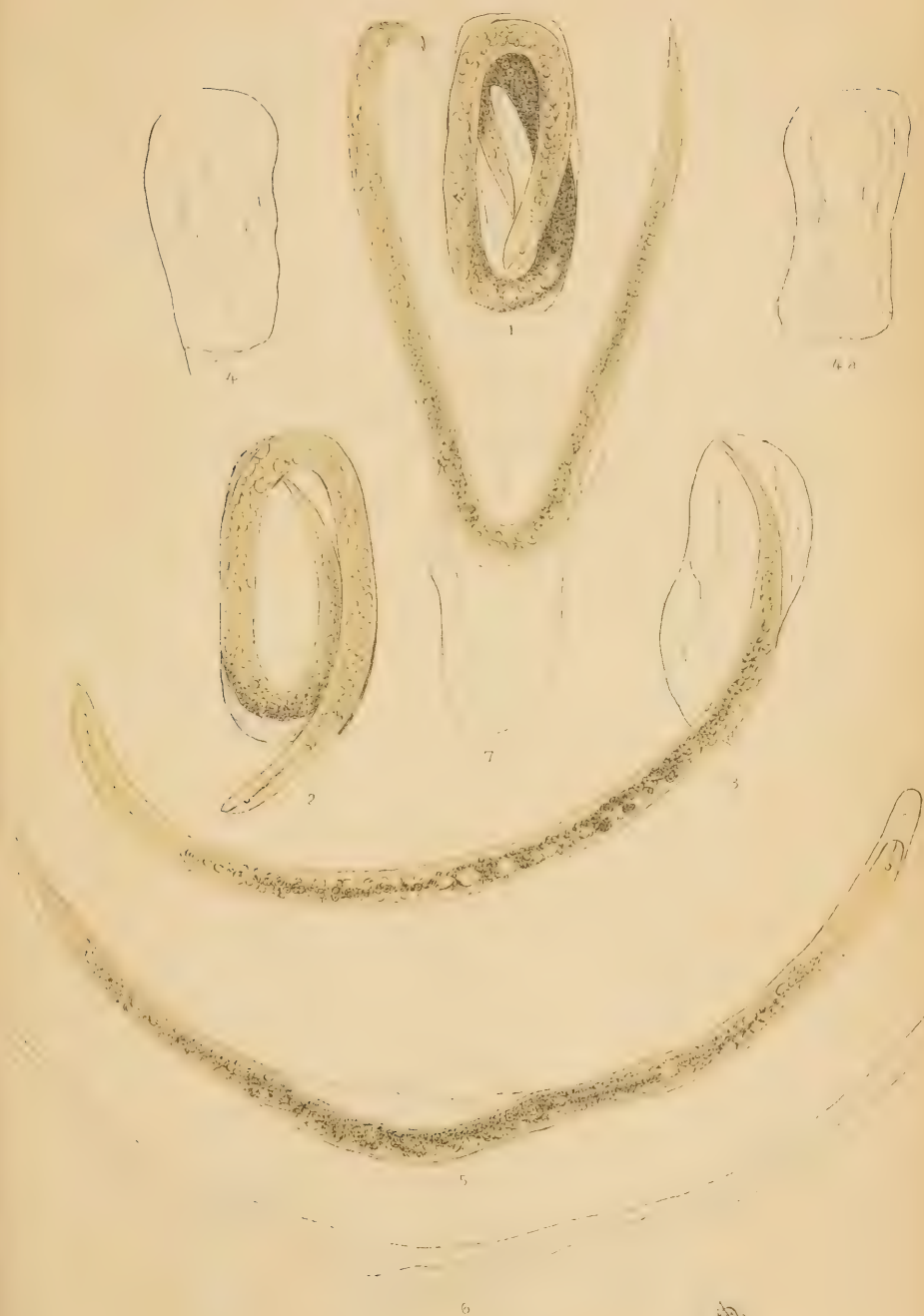


17.



18.

PLATE XI.



DEVELOPMENT OF ANGUILLULA.

PLATE XII.



DEVELOPMENT OF ANGUILLULA.

PLATE XIII.



DEVELOPMENT OF ANGUILLULA.

PLATE XIV.



GROWTH AND CHANGES IN THE FEMALE ANGUILLULA.

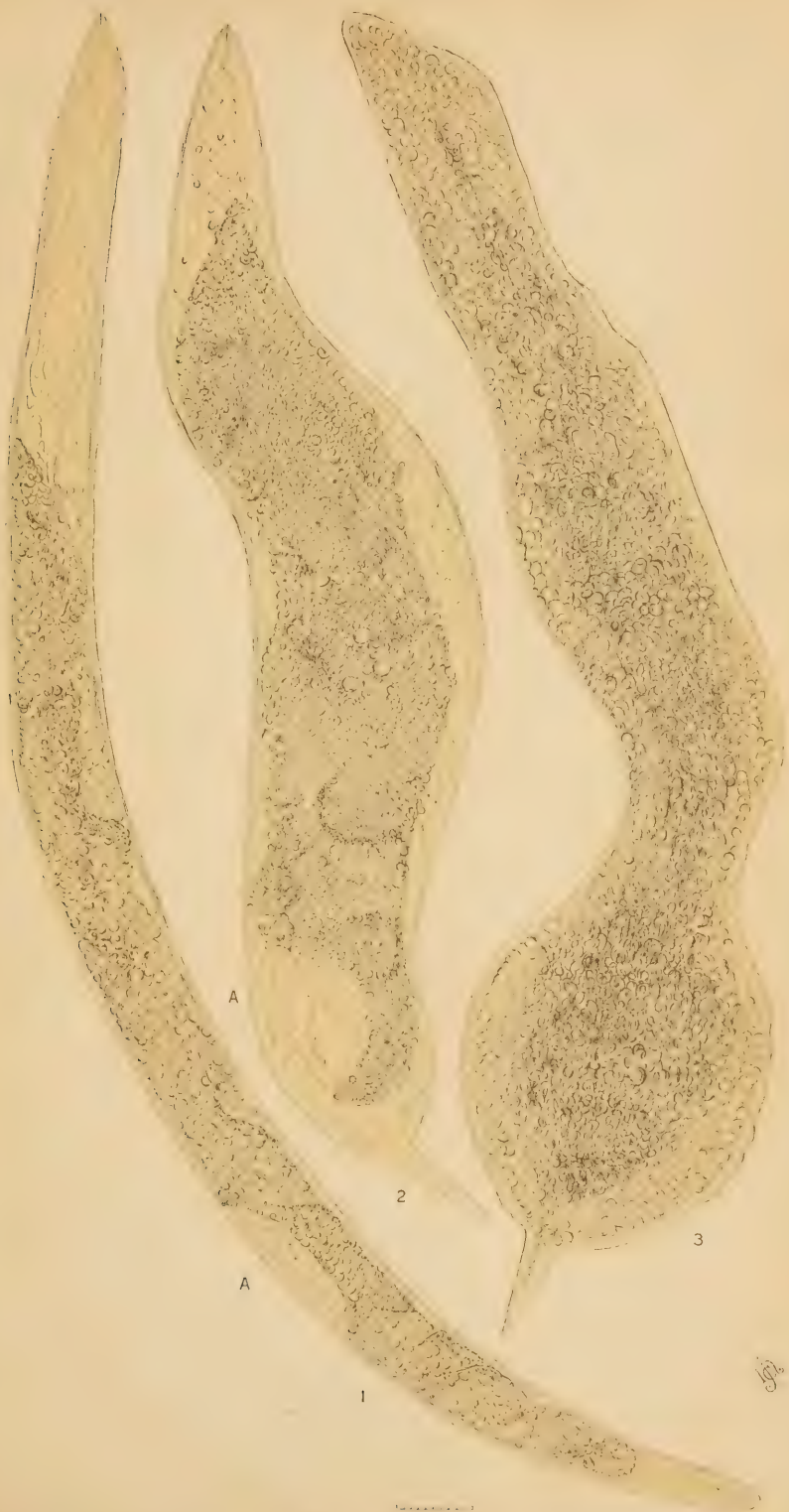


PLATE XVI.

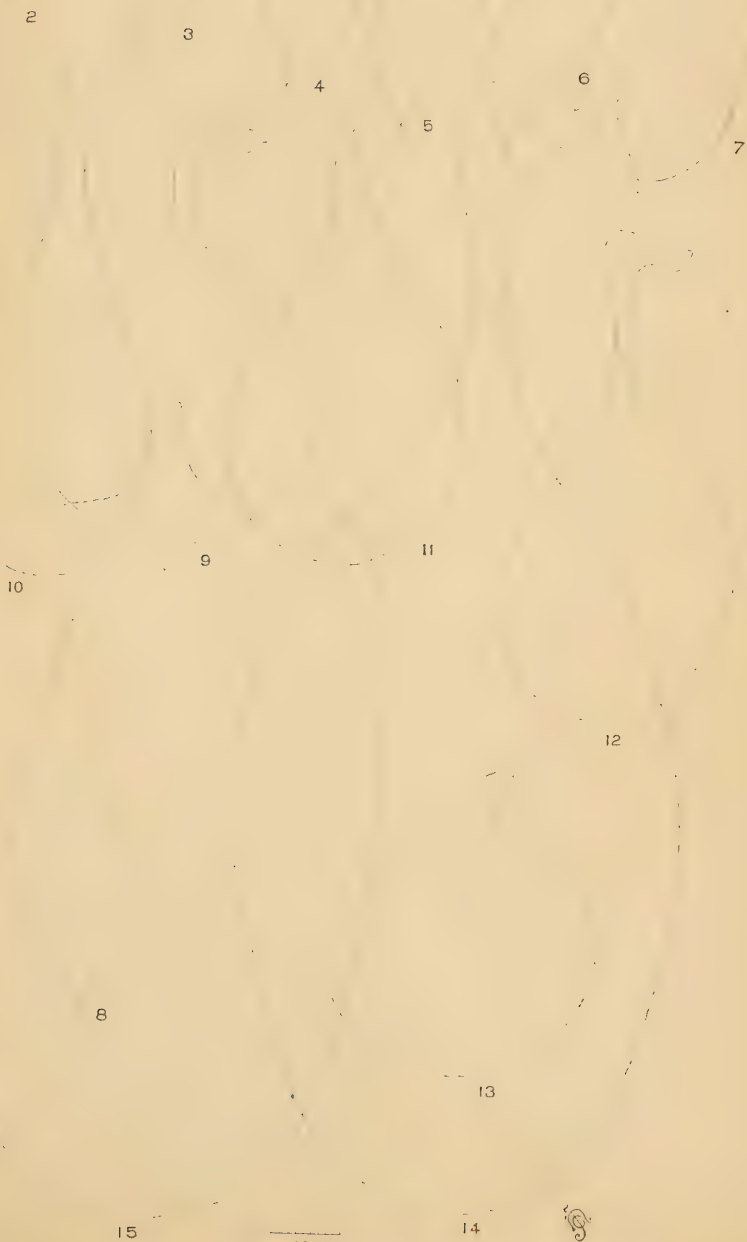


PLATE XVII.

9

2

6

8

1

3

4

5

7

10
2,500 in.

10

PLATE XVIII.



ANGUILLULA

Fig. 1

GRAVID FEMALE ANGUILLULA, SHOWING CYSTS IN UTERO.

PLATE XIX.



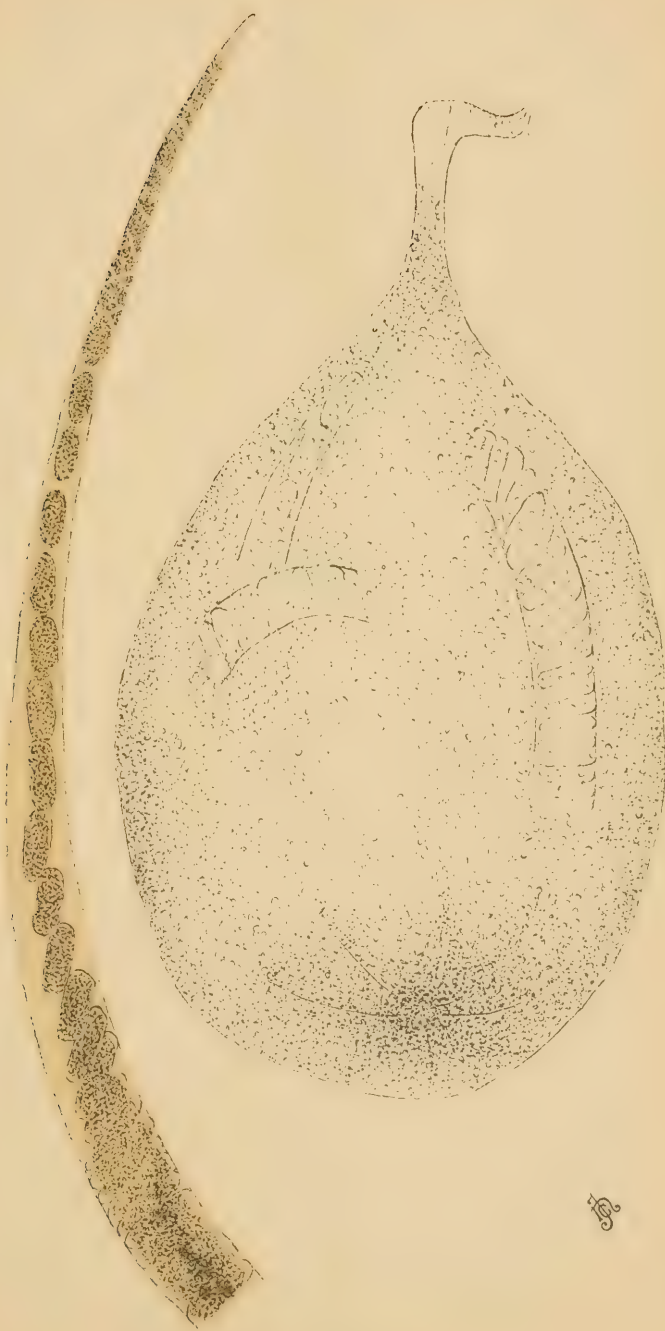
36

10
2,500 in.

FEMALE ANGUILLULA, SHOWING EXPULSION OF YOUNG.



PLATE XXI.



$\frac{10}{2,500}$ in.

ARRANGEMENT OF CYSTS IN FEMALE ANGUILLULA IN UTERO.



U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 21.

R E P O R T
OF A
TRIP TO AUSTRALIA
TO INVESTIGATE THE
NATURAL ENEMIES OF THE FLUTED SCALE.
BY
ALBERT KOEBELE.

(MADE UNDER DIRECTION OF THE ENTOMOLOGIST.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.



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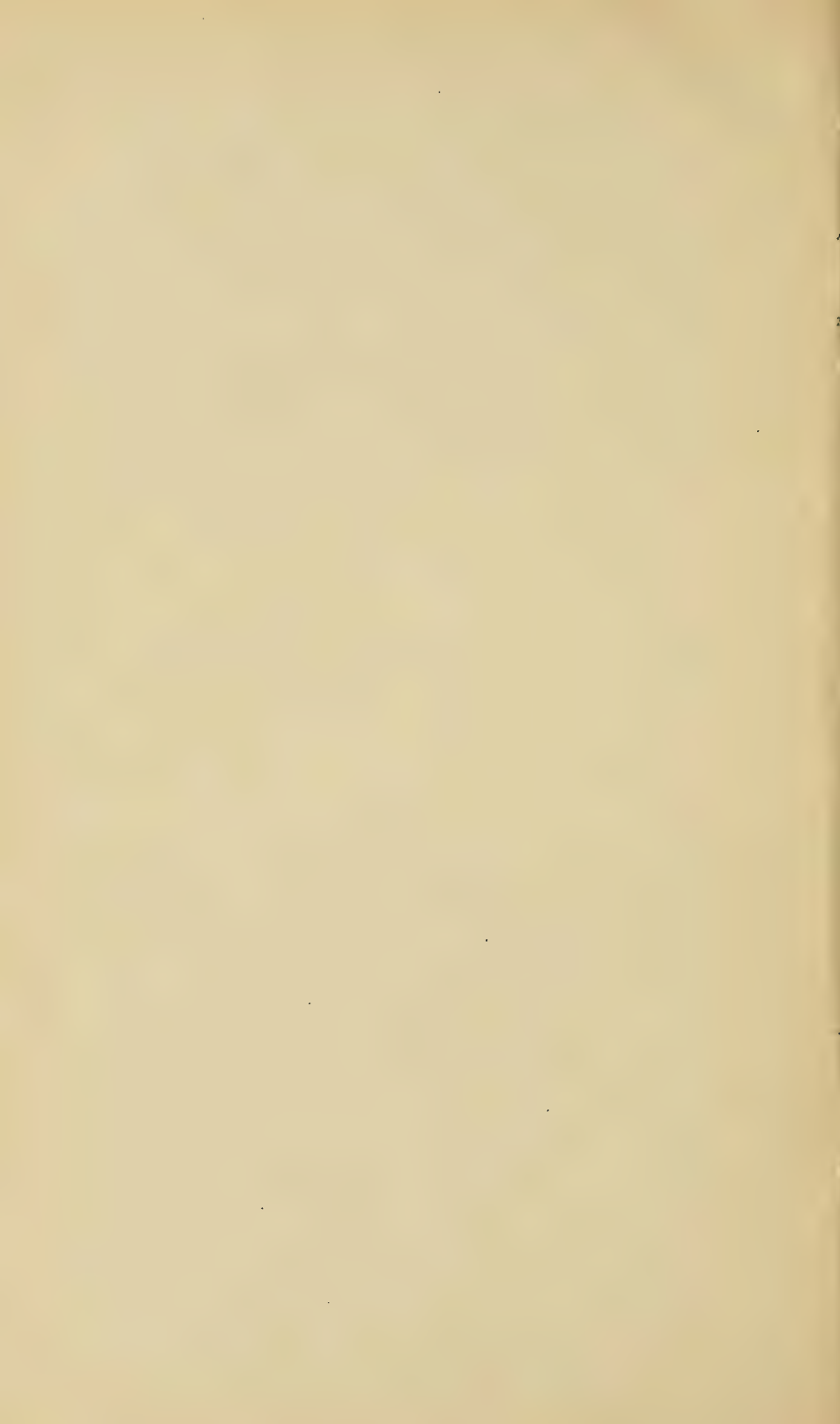
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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY,

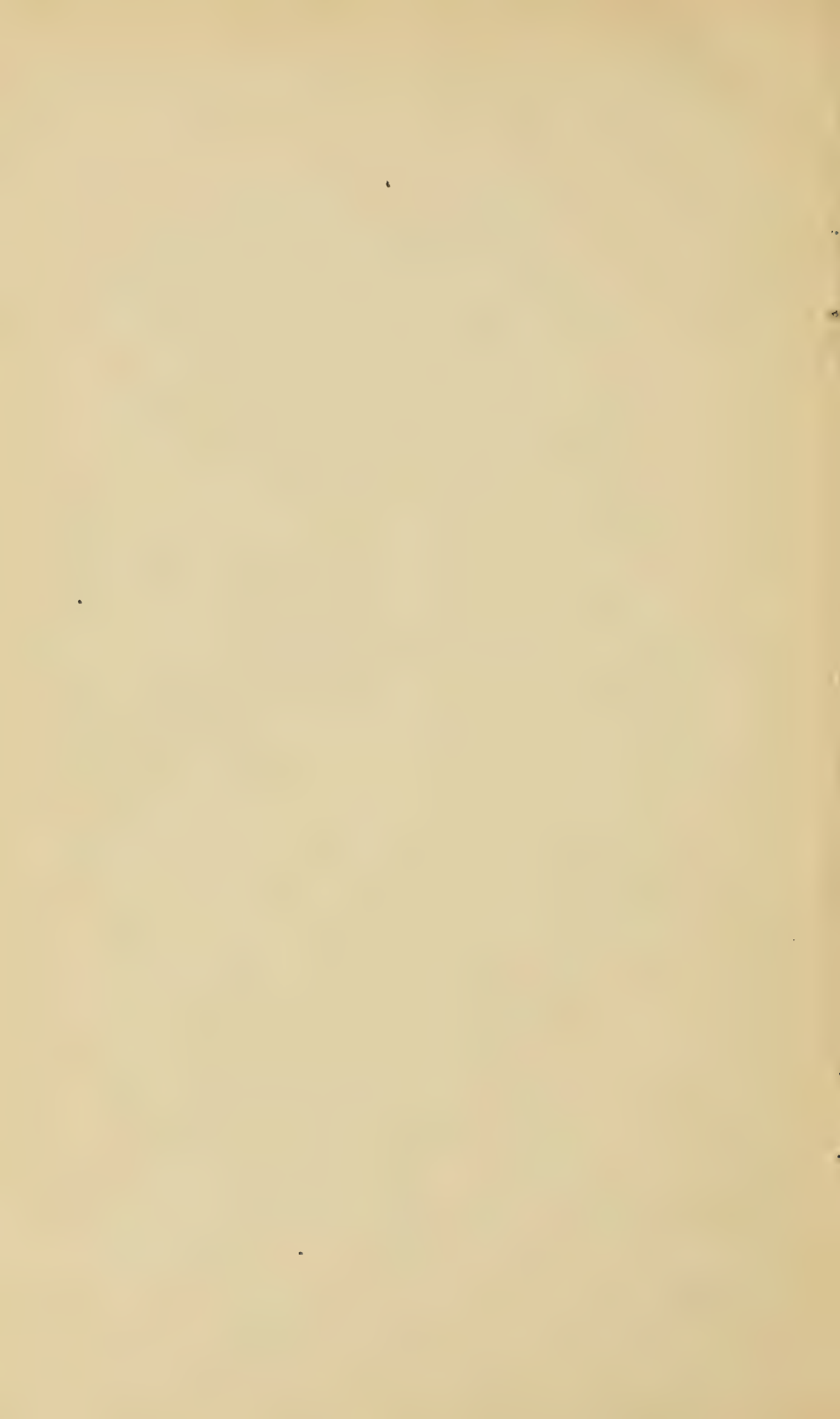
Washington, D. C., November 22, 1889.

SIR: I have the honor to submit for publication Bulletin No. 21 of this Division, being the report of Mr. Albert Koebele upon the Fluted Scale (*Icerya purchasi* Maskell) and its natural enemies in Australia. I had intended to incorporate it in my forthcoming annual report, but the limited space allotted to that report makes it necessary to publish this as a separate bulletin.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.



INTRODUCTION.

The following report by Mr. Albert Koebele, one of the California agents of the Division of Entomology, gives an account of his trip to Australia, made during the late summer and fall of 1888 and the winter of 1888-'89, under instructions from this Department, for the purpose of investigating the Australian natural enemies of the Fluted Scale (*Icerya purchasi* Maskell) with a view to introducing the most efficient of them into California.

Failing to secure a specific appropriation from Congress for this purpose, although assisted in the attempt by the California delegation, and particularly by the Hon. C. M. Felton, and failing also to secure the removal of the clause restricting travel to the limits of the United States, we were led to accomplish the result through the kindness of the Department of State, in connection with the Melbourne Exposition, an arrangement having been made whereby two of the salaried agents of the Division should be temporarily attached to the Commission, their expenses, outside the United States, to be defrayed by the Commission, within the sum of \$2,000. The warm thanks of this Department are due to the Department of State for this coöperation, and particularly to the Hon. Frank McCoppin, commissioner-general to the Exposition, to whom the matter was submitted by the State Department for approval. Mr. McCoppin at once accepted the proposition, and upon Mr. Koebele's arrival in Australia helped him in every way possible to make the experiment successful.

Mr. Koebele was sent, as just stated, for the specific purpose of studying and importing the natural enemies of the Fluted Scale, while the other agent, Mr. F. M. Webster, was sent to make a special report to the Commission on the agricultural features of the Exposition. Mr. Webster's report has been sent to the Commission, and was formally submitted to Mr. McCoppin. A copy of the present report, although purely entomological, and having little relation to the Exposition proper, has also been transmitted to Mr. McCoppin, as the results of the mission are, and ever will be, connected with his exposition work.

While a number of other entomological matters are referred to in the report, Mr. Koebele never lost sight of the main object of his mission. How successful it has proved late reports already published in INSECT

LIFE, and elsewhere, have abundantly testified. They have more than justified the anticipations expressed in my last annual report:

We fully expect to learn of the increase and rapid spread of this new introduction as well as some of the other predaceous species which have been introduced, and to find that in a comparatively few years the orange groves of southern California will be kept measurably freed of the pernicious Fluted Scale without so great an effort on the part of the growers or so great expense in destroying it. That nature will, with the new conditions induced by these importations, come to the relief of the fruit-grower, and that this interesting experiment will result in the ultimate saving of untold millions to the people of the Pacific Coast is our sincere belief which we hope to see verified. Not that we expect the *Icerya* to be ever entirely exterminated; but it will be kept under subjection so as to be comparatively harmless, as it is in its native country.

One of the insects imported, viz, the Cardinal Vedula (*Vedula cardinalis* Mulsant), has multiplied and increased to such an extent as to rid many of the orange groves from *Icerya* and to promise immunity in the near future for the entire State of California. In fact, the rapid multiplication and the effective work of this little beetle are almost incomprehensible until we come to consider its power of increase in a climate like that of southern California, where there is scarcely any cessation in its activities.

A careful account of the transformations of the Vedula has been prepared by Mr. Coquillett and was published in INSECT LIFE for September, 1889, pages 70 to 74. I reproduce the figures in connection with Mr. Koebele's report in order to familiarize those who have not yet seen it with its appearance. I have also had some other figures made to accompany the report.

The period from the laying of the eggs until the adults again appear occupies less than thirty days for the Vedula. At this rate of increase, calculating that three hundred eggs are laid by each female, and that one half of these produce females, it will readily be seen that in six months the offspring of a single female beetle may under favorable circumstances amount to over twenty-two trillions. So far it has not been noticed to prey upon any other insect than the Fluted Scale, a fact which accounts somewhat for its exceptionally rapid work and renders the outlook extremely encouraging.

Of the other enemies of the *Icerya* referred to and more particularly mentioned in the latter part of Mr. Koebele's report, none of them have so far given much promise, and there is risk of their not being colonized by virtue of the extraordinary spread and increase of the Vedula, which has swept away from whole regions the Fluted Scale, upon which they depend. This contingency should have been avoided and I very much regret that they have not become established in California, because their establishment, and especially that of the little Dipteron, *Cryptochaetum iceryae*, would have helped in the general subjection of the pest and would be particularly valuable whenever the Vedula, for whatever reason, at any time practically forsakes a given locality.

C. V. R.

LETTER OF SUBMITTAL.

ALAMEDA, CAL., July 17, 1889

SIR: I herewith submit my report upon the study of *I. erya purchasi* in Australia and New Zealand and the introduction of its parasites and enemies into California, undertaken under your direction and in accordance with your letter of instructions.*

Respectfully yours,

ALBERT KOEBELE,
Special Agent.

Prof. V. C. RILEY,
U. S. Entomologist.

*The following is extracted from the letter of instructions:

WASHINGTON, July 3, 1888.

* * * As you are already aware you are sent to Australia for the purpose of making an investigation of the parasites and other natural enemies of *Icerya purchasi* with a view of introducing them into California. It will be necessary for you to go to Adelaide to see Mr. Frazer S. Crawford, who sent over the first Dipterous parasites and the *Calostomas* (or rather *Monophlabus crawfordi*). This Dipterous parasite has been named by Dr. Willsiton *Lestophonus icerya*, and at Adelaide you will probably be able to study this insect carefully. Make the most careful investigations where you can learn of the occurrence of *Icerya* and find all of its natural enemies in Australia. Find out also the periods at which these parasites oviposit and ascertain the season at which success in importation will be most likely with each and all of them. Once on the ground you can see for yourself just what will be necessary to be done in order to bring about this result. You should also endeavor to place the Department in correspondence with as many observers as you can interest in the subject, and should by all means endeavor to get at least one man who will be able to devote some time to the matter and continue observations after you leave. It is barely possible that we may be able to re-imburse some such person for the time expended, but for this I will write you later, if indeed I do not see you personally in Australia in November. You will, of course, inquire immediately upon arriving in Melbourne concerning the largest orange-growing districts in Australia, and also make inquiries as to the best places for observing *Icerya*, aside from Adelaide. If you will visit the Botanic Gardens in Melbourne you will be able to get some information there. Baron von Mueller, formerly director of the Botanic Gardens, is still a resident of that city and you will find him a very well-informed person to consult. I inclose you letters of introduction both to Mr. Crawford and Baron von Mueller. * * *

On this trip your salary will be paid as usual by this Department, but your expenses by the Department of State through Mr. McCoppin. * * *

REPORT OF THE FLUTED SCALE OF THE ORANGE AND ITS NATURAL ENEMIES IN AUSTRALIA.

By ALBERT KOEBELE.

In accordance with the commission received from the Hon. Norman J. Colman, United States Commissioner of Agriculture, and your letter of July 3, 1888, I left San Francisco on August 25, and arrived at Auckland, New Zealand, on September 14, where some hours were spent in getting information in regard to *Icerya*. I visited Mr. W. Will, editor of the *New Zealand Herald* and *Auckland Weekly News*, who then, and subsequently on my later visit, gave me valuable information in regard to the occurrence and disappearance of *Icerya* in the Auckland districts, as well as many other points of interest in horticulture; and also Mr. T. F. Cheeseman, curator of the Auckland Museum, who readily accompanied me to a place full of *Albizzia* (*Acacia*) *lophantha*, Bentham, which had been about three years previously completely covered with *Icerya*. I made a careful search for specimens on these trees, yet only four full-grown females with large egg-sacs could be found. On one of the scales two rather large mites were feeding, attached to the under side; and the masses of old and moldy remains of *Icerya* were still visible on the trunks of trees.

A residence on which formerly were many orange trees was also visited. There all of the trees had been cut down on account of the numerous scales, and at the time of my visit no *Icerya* could be found and none were observed during the year as the proprietors informed me. No one was able to state the exact reason of the disappearance of the scales; some disease was the supposed cause.

The steamer left Auckland the following day and arrived in Sydney, New South Wales, September 20. I remained there for four days in search of *Icerya*. On my first walk a number of them were discovered at the town hall premises, infesting a *Pittosporum* (*P. undulatum*), and the succeeding days a few more were found in one of the public parks, also on this *Pittosporum*. A large isolated acacia tree full of the scales was found in front of a private house in the eastern part of Sydney; all were full-grown females with more or less developed egg-sacs and ap-

parently in a healthy condition. As the trees infested were all inclosed, no proper examination could be made and the few obtained at the town hall showed no trace of parasites. A trip was also made to Parramatta, about 14 miles to the west of Sydney, to look into some of the orange orchards. I found nearly all the trees badly infested with the red-scale (*Aspidiotus aurantii* Maskell, Fig. 1), and still worse with what I con-

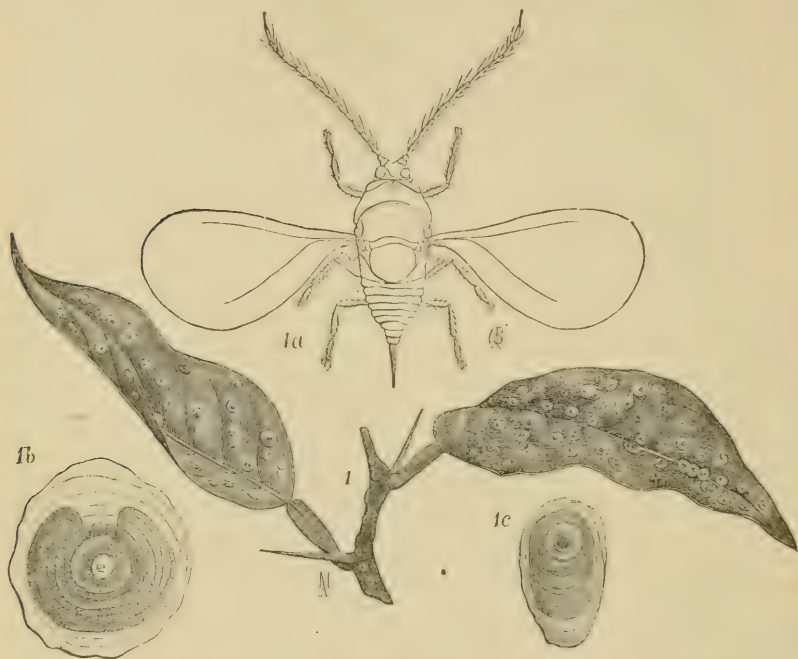


Fig. 1.—*Aspidiotus aurantii* Maskell: 1, scales on leaf of orange, natural size; 1a, adult male; 1b, scales of female; 1c, scale of male—enlarged (after Comstock).

sidered to be *Mytilaspis glorerii* Packard.* Indeed, some of the trees are completely covered by this latter scale, having the appearance of an old coat of whitewash on the bark which had partly fallen off. None of the several orange growers there visited had ever seen an *Icerya* or was familiar with the insect. I left Sydney on the 24th and arrived in Melbourne the following day, having in the meantime, through the kindness of the United States consul, obtained a free pass over the New South Wales Railway, which courtesy was shown me by all the colonies subsequently visited. Indeed, I can not speak too highly of the kindness shown me by all the Government officials, and of the interest they took in the successful execution of my work. I remained in Melbourne for six days, during which time I visited Baron Ferdinand von Mueller, to whom you had given me letters of introduction. This gentleman assured me that the *Icerya* never became extensively injurious in Aus-

*A careful study of the pygidial characters of this scale shows it to be much nearer *M. pomorum* than *M. glorerii*. It seems, however, to be distinct from the former and will probably prove to be new.—C. V. R.

tralia. Occasionally and in certain spots they became numerous, but always disappeared again. I also met Mr. C. French, Baron von Mueller's assistant, who has had some experience in entomology. He claims that the scale has been known to him for thirty-four years, yet he has never seen it in large numbers.

At the Zoological Gardens I found on a species of *Eucalyptus* a coccid in such numbers as to cover the under side of all the larger branches and the stem in part. Many of the winged males were secreted among the crevices of bark, with their two long white setous hairs protruding. Numerous larvæ of a coleopter were found under chips of bark feeding upon the scales, apparently belonging to some clerid. I never met with these larvæ again in my later researches nor with the coccid mentioned. A great variety of scales was observed at Melbourne; the most pernicious amongst them, a species of *Aspidiotus*, deserved attention. This is *A. rossi* Crawford, figured on his plate 18 of the Coccidæ, but as yet no description has appeared to my knowledge. I have seen olive trees completely covered by this scale; it will attack almost any kind of tree or shrub as I later observed. Many of the shrubs in the Botanical Gardens in Melbourne infested by this scale were in a dying condition. The introduction of this pest would be of serious consequence to the United States and we should be on our guard against this as well as a second species of waxy scale, probably a species of *Ceroplastes*. This last is covered by a thick, smooth, white, waxy matter which effectually protects it. Nothing would destroy this scale, except remedies against the newly hatched larvæ, which, before they exude any wax, are easily killed. The insect was observed all over eastern Australia, and it was numerous in the Botanical Garden at Sydney and in the woods near Brisbane. At the Botanical Gardens they could find no remedy except cutting down the infested plants. I recommended a strong resin wash for the newly hatched larvæ. No *Icerya* could be found during my short stay at Melbourne.

I arrived at Adelaide, South Australia, on October 2, with letters of introduction to Mr. Frazer S. Crawford, of the surveyor general's office, who received me very kindly and promised me his assistance, which promise he honorably fulfilled throughout my stay in Adelaide. I saw the man who discovered the parasites of *Icerya* (*Lestophonus iceryæ*), and, indeed, felt very happy when he promised to show me a large colony of the scales on the following day. Early the next morning Mr. A. Molineux, agricultural editor of the *South Australian Register and Adelaide Observer*, and proprietor of the *Garden and Field*, showed me about a dozen orange and lemon trees in a private garden in the suburbs of Adelaide all more or less infested with *Icerya*, and had been so for the previous two years. The scales were nearly all full grown, or rather nearly all of them had begun to exude cottony matter and deposit eggs, yet they were not quite so far advanced as those observed at Sydney.

The very first scale examined contained nine pupæ of the parasitic fly, *Lestophonus*, and the scale was still living. Nearly all of the many

others examined proved to have either larvae or puparia within them; none of the flies had at that time made their appearance. I attended the gardeners' meeting at Adelaide on October 6, in order to get information as to the occurrence of *Icerya*, yet but very few of the gentlemen were acquainted with the insect. To show how rare *Icerya* is in South Australia, Mr. J. G. O. Tepper, of the museum at Adelaide, a qualified entomologist, who has collected insects all his life, has known *Icerya* only for the last two years. He never met before this with any specimens in all his collecting trips through South Australia. On October 15 I made a trip with Messrs. Crawford and Tepper to North Adelaide, where some *Icerya* were said to exist; we found there in one garden a few orange and lemon trees with the scales, which were subsequently collected for shipment. In another garden, and also on orange, an oc-

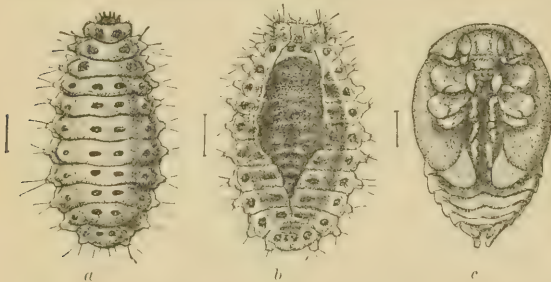


FIG. 2.—*Vedralia cardinalis*: a, full grown larva; b, pupa, dorsal view, inclosed in last larval skin; c, pupa, naked, ventral view—all enlarged (after Riley).

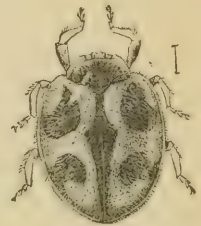


FIG. 3.—*Vedralia cardinalis*, adult—enlarged (after Riley).

casional specimen was found. I discovered there, for the first time, feeding upon a large female *Icerya*, the Lady-bird, which will become famed in the United States—*Vedralia cardinalis* (Figs. 2 and 3). I called the attention of both the gentlemen to this insect, yet neither of them had ever seen it nor knew the beetle. Mr. Tepper has charge of a large collection of insects, and especially of Coleoptera, at the South Australian Museum. Mr. Smith, the proprietor of the nursery, also called my attention to a beetle, a curculio, which is very destructive to olive-trees, eating the young shoots and leaves of the plants during the night and secreting itself in the ground during the day-time (Fig. 4).*



FIG. 4.—Olive Snout-beetle—enlarged (original).

Through the bureau of forestry at Adelaide I was informed that a colony of *Icerya* existed at Mannum, on the Murray River, and a trip to that place was made on October 18. In two gardens *Icerya* was present; in one of them they existed on only a few of the many orange-trees, and none examined showed any parasites, while in the other on two

* This is an Otorhynchid unknown to us, and will have to be referred to a specialist abroad.—C. V. R.

trees that were infested many of the scales were parasitized. In addition to the parasites, numerous larvæ and eggs of a lace-winged fly (*Chrysopa*) were observed, the larvæ preying upon the scales and chiefly upon their eggs. They were covered so much with the cottony matter of *Icerya* as to resemble this insect very closely, and were difficult to pick out from the torn masses of egg-sacs. I also observed here a coleopterous (*Coccinellid*) larva, seen before at Adelaide, feeding on the scales, and this proved to be that of the *Vedalia*. All the scales here, as well as all the predaceous larvæ found feeding upon them, were collected and taken to Adelaide to be shipped to California, together with those found at the latter place. They were kept boxed in a cool cellar. The scales in Adelaide and suburbs were collected on October 24 and 25 at a place in North Adelaide. Nearly every one of the *Iceryas* exposed to light and sun contained parasites, and many of these had already left, as numerous holes were visible. Of the scales found on a small and bushy mandarin tree, where they were excluded from the sun, only a few contained parasites, but the larvæ of the *Chrysopa* were abundant. Most of the larger egg-sacs of *Icerya* were torn by them and the contents devoured.

I observed also that many of the young scales, only sufficiently large to contain a single puparium of the fly, were infested, the expanded skin of *Icerya* forming a thin covering over the puparium of the *Lestophonus*. This was observed at all places where *Icerya* occurred. No doubt the eggs of the pest must be deposited while the scales are yet quite small, probably even before the first molt, and certainly later, as the scales will go on feeding and increasing in size until the larvæ within them pupate. At this time large numbers of the scales were hatching and also of the flies. Only one living fly was observed on October 24 while collecting the scales, sitting between two large egg-masses and hardly visible to the eye. This and a second specimen taken under similar circumstances were the only ones I observed in nature. I have never met with a single specimen depositing eggs or even sitting on an *Icerya* nor flying around. I finished collecting for my first shipment on the 25th and estimated that I had about 6,000 *Icerya*, which in return would produce at an average about four parasites (*Lestophonus*) each. They were packed partly in wooden and partly in tin boxes. Small branches generally full of scales were cut so as to fit exactly lengthwise into the box. With these the boxes were filled and all loose scales placed in between, plenty of space remaining for any of the insects within to move about freely without danger of being crushed by loose sticks. Salicylic acid was used in small quantities in the tin boxes to prevent mold, yet these, as I have been informed by Mr. Coquille, arrived in a more or less moldy condition, while those in wooden boxes always arrived safe. In addition, Dr. Schomburgh, director of the botanical gardens at Adelaide, kindly fitted up for me a Wardian case which was filled with living plants of oranges and *Pit-*

tosporum in pots. Large numbers of *Icerya* were placed in this, and such larvæ as were found feeding upon them, including some of a *Scymnus** (Fig. 5), only occasionally found with *Icerya*, yet very abundant on various *Eucalyptus* scales, especially on *Eriococcus eucalypti*. Of this I sent large numbers to California in my later shipments, as they were easily collected by the hundreds under bark of *Eucalyptus* infested with this *Eriococcus*. Mr. F. M. Webster brought me the same insect in numbers from Tasmania, together with the *Eriococcus* on *Eucalyptus*. The object of this was to have the *Lestophonus* go on breeding within the case during the voyage. No



FIG. 5.—*Scymnus restitutor*—enlarged (original).

doubt many infested scales arrived in Los Angeles.

I found on examining the tree, on April 12, 1889, under which this case had been placed with a tent over it, that from several of the *Iceryas* the *Lestophonus* had issued. This case, as Mr. Coquillett informed me in letter of November 30, arrived in good condition, except that the putty had been knocked off in several places, leaving holes large enough for the parasites to escape. Before opening the case he found two coccinellid larvæ crawling on the outside, and these when placed with the *Icerya* attacked it at once. He further said that there were only about half a dozen living *Chrysopa* adults. This would show that the *Lestophonus* was still issuing on arrival in California and all turned out more favorably than I had anticipated on seeing the box handled in such a rough manner by the steamer hands at Sydney, to which point I accompanied this as well as all the subsequent shipments. I expected little good would come out of this method of sending and therefore concluded to send only small parcels on ice thereafter, as had been partly done at first. If once the insects could be placed in good condition in the ice-house on the steamer just before leaving, where a temperature of 38° Fah. at first and about 46° Fah. on arrival in San Francisco existed, they must arrive safely. To accomplish this, the parasites with their hosts were all collected the last three days before leaving Adelaide, and on arriving home were immediately placed in a cool cellar. On the trip from Adelaide to Sydney, which takes two days by train, my insects came generally in an ice-box on the sleeping-car.

On November 2 I made a trip to Gordon, 11 miles north of Sydney, Mr. James Harold, agricultural reporter of the *Town and Country Journal*, Sydney, having furnished me with the address of a prominent fruit-grower there. Mr. Harold has traveled much over Australia gathering information for his paper, yet, as he assured me, he never met with an *Icerya*. The same answer was received from the gentleman at Gordon, who has been living in the colony for thirty-four years and has raised oranges for thirty-two years. He knew only the three scales upon

* Dr. Sharp has since described this as *Scymnus restitutor* (Insect Life, I, 364).

oranges, viz: *Lecanium oleæ* (Fig. 6) and the *Mytilaspis* and *Aspidiotus aurantii*. This latter is not doing any serious damage to his trees, providing they are well taken care of, yet he assured me that in some parts of the colony it is impossible to raise oranges on account of the ravages of this scale. For the *Mytilaspis* he uses sulphur and lime as a wash, applying it with a paint brush. This he claims need only be repeated every three years, as during this time the trees remain comparatively free. The mixture is prepared in the following way:

Unslacked lime, two parts; sulphur, one part; water is poured on this in sufficient quantities to boil and unite with it. It is applied as a white-wash to the trees and to prevent injury should not be too strong

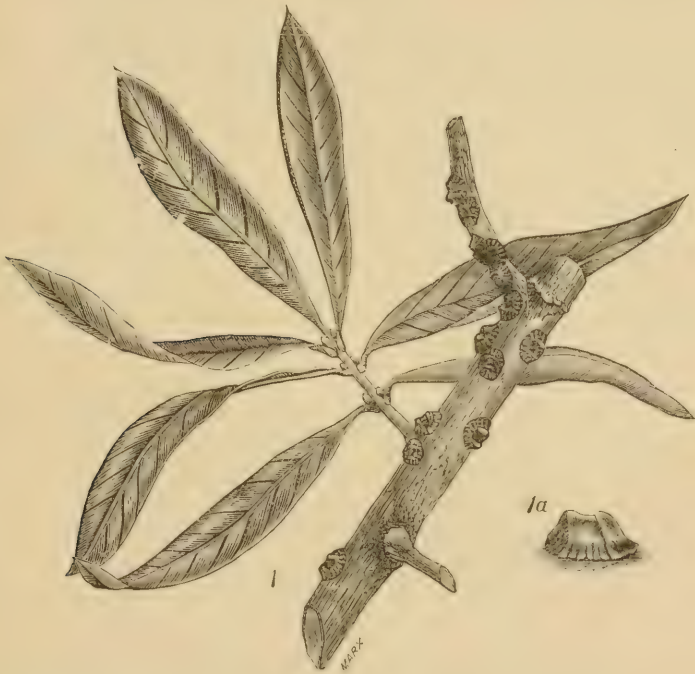


FIG. 6.—*Lecanium oleæ*: 1, adult females on olive leaves—natural size; 1a, female—enlarged (after Comstock).

Besides the scales, an *Aphis* appears occasionally on orange and peach trees. Two beetles are numerous and destructive to the melon vines here. One of them found at the time is a *Diabrotica*, often received by Mr. Crawford, of Adelaide, as doing great injury to the melon tribe. This gentleman, however, claims that all injury can be avoided by dusting powdered lime over the plants. The beetles, he said, will not attack leaves thus treated. I found here, as well as all over Australia and New Zealand, the Woolly-Aphis (*Schizoneura lanigera*), yet they could be seen only on the branches, as all or nearly all the apples raised in the colonies and New Zealand are said to be grafted on blight-proof

stock. For this purpose, the Northern Spy of our continent is considered the best; next comes the Majetin, as Mr. Will, of Auckland, informed me. The Irish peach was standing completely free of Aphis between badly infested trees. A large number of blight-proof trees are sold by nurserymen in Australia and New Zealand, and only such are planted in these countries as far as the roots are concerned. Mr. Will said that the Northern Spy will produce the best roots; on this is grafted the Majetin as the stem, and any desired variety may be selected for the upper part or branches. At this place I observed a small black and lemon-yellow lady-bird (Fig. 7) feeding upon the Woolly Aphis; the same was also observed at Toowoomba, Queensland, under similar circumstances.* I did not meet with it outside of these places. No *Icerya* could be found on the orange trees, but the same day, two young specimens were found in the woods, about 2 miles distant, one of them on a pea-vine and the second on a species of *Salix*, both near the ground.



FIG. 7.—Lady-bird feeding on Woolly Aphis—enlarged (original).

November 5 I visited Mr. Joseph Purser at Castle Hill, to the west of Sydney, also a prominent fruit-grower. No *Icerya* were found on the numerous orange trees at this place. Mr. Purser reports having met with an occasional specimen only on his orange trees, never more than half a dozen. A short distance from the orchard I noticed a small pond on the edge of which were growing a few small bushes of *Acacia*. On examination I found two large *Iceryas* with egg sacs and several empty skins of scales. Mr. Purser informed me that in former years he has often seen the scales upon trees growing along river banks. During this same day, while searching through the bush, I found upon the needle-bush *Hakia acicularis*, growing amongst numerous *Acacia longifolia*, a well developed *Icerya* fastened to the main stem. A careful search was made on all the plants growing there, yet with the exception of a peculiar *Cælostoma* upon *Acacia*, no scales could be found. One specimen of *Icerya* was found on this *Acacia* at the botanical gardens in Adelaide. Mr. Purser, who is also much troubled with the *Mytilaspis* mentioned, used as a remedy kerosene-tar, 1 pint; soft-soap, 3 pounds; sulphur, 5 pounds. These are boiled in 10 gallons of water and the trees washed with this mixture with a paint-brush, only the trunk and larger limbs being treated. The gentleman claims that all the scales on trees so treated will be killed and the trees will remain free from scales from seven to nine years.

I returned to Adelaide on November 8, as I considered that the best field to obtain the material. On the 15th a trip was made about 300 miles north of Adelaide, but I found nothing of interest in the insect line on this journey, with the exception along the road of large num-

* This species has been sent abroad for determination,—C. V. R.

bers of locusts traveling south in search of food, nothing being left for them in the interior to feed upon. The country around Quorn was so dry and hot that some *Eucalyptus rostrata* in a dry river-bed were all the green vegetation that could be seen, and the locusts still met with were unable to feed. Finding the search for *Icerya* in this district useless, I returned to Adelaide, where subsequently new colonies were discovered for shipment. In conversation about the grasshoppers en route, a gentleman remarked that only in such unusually dry seasons as the present would the locusts migrate, there being no food left for them in the interior of South Australia. Those around Quorn, he remarked, left in a southeasterly direction down the valley toward Adelaide, while those coming from the interior went towards Spencer's Gulf. On my trip I observed them most abundantly about Black Rock traveling south, not in clouds but scattered and never very high, similar to our *Caloptenus devastator* in California in 1885.*

November 29 I began collecting material for my second shipment. Already on some of the trees, well exposed to sun, about 90 per cent. of the flies had left the scales, while on the trees in more shady places more than half of the parasites were still within their hosts. Not a single fly was observed, and yet they must have been about in large numbers. Instead of this, I noticed sitting and walking about the scales a peculiar Chalcid† (Fig. 8); this was suspected to be a secondary



FIG. 8.—*Euryischia lestophoni*, dorsal and side views—enlarged (after Riley.)

parasite, and during the day I noticed them ovipositing in the infested *Iceryas*. The Lady-birds were at that time quite abundant in egg, larva, pupa, and imago states, and special pains were taken not to miss any of these during the collecting. The following four days were

* We have sent specimens of this locust to M. Henri de Saussure, of Geneva, Switzerland, for determination, but at the date of going to press have not received his reply.—C. V. R.

† This is the species referred to in our annual report for 1888, p. 92, under the MS. name *Euryischia lestophoni*.—C. V. R.

spent in gathering *Icerya* and its enemies. Many of the secondary parasites were again noticed, yet not a single *Lestophonus*. I gathered during this time probably six thousand scales, and hardly a specimen was noticed among them that was not parasitized by the *Lestophonus*. All of them contained either puparia of the fly or empty holes where the flies had issued. Knowing that if we should introduce the secondary parasite the good work of *Lestophonus* on *Icerya* would be greatly restricted, I sent the following notice to Mr. Coquillett, and also to your office.

On account of a parasite of *Lestophonus iceryæ*, remove the infested scales that I send from the tree they were placed on, after six weeks, and transfer into large glass jars; examine daily by stupefying the insects that have issued, with chloroform or ether, empty contents on table, pick out the flies and destroy their parasites. Form a new colony with every consignment you receive.

In your letter of January 3 in regard to this secondary parasite you wrote:

The parasite bred from *Kermes* and the one from confined *Icerya* and which you think to be parasitic upon *Lestophonus* are different species of the same genus. The genus is an entirely new one belonging to the Chalcid subfamily *Elasminiæ*. This subfamily is an extremely interesting one, and up to the present time has contained only the typical genus *Elasmus*, so that this finding of a new genus is important. *Elasmus* contains both secondary and primary parasites, so that it will be necessary to secure pretty good evidence regarding this new form before we can accept it as either one or the other.

From seventy-five specimens of *Kermes* no *Lestophonus* was bred. On the 26th I left Adelaide on my way to Sydney, with what I considered even a better shipment than the first. Unfortunately this lot arrived in a bad condition at San Francisco, owing to a gale on the route when the parcels fell off the shelving in the ice-house, in which they had been placed, and most of them were crushed by cakes of ice falling on them. In my opinion, even such severe treatment as this would not destroy so very many of the pupæ of *Lestophonus*, which are not soft, and if crushed out of the scale will produce flies if properly taken care of later, as I had ample opportunity to observe while in Australia.

Among this lot of things were also about fifteen hundred eggs of the *Chrysopa* which were collected on Kangaroo Acacia (*A. armata*) infested by a *Dactylopius*, which is often taken to be *Icerya*. The scale is sometimes so abundant that the plants are entirely covered with it. This was the case during my visit, and, as Mr. Crawford informed me, also in 1882. Mr. Maskell, to whom specimens were forwarded by Mr. Crawford, said that the insect belongs to the *Dactylopiinæ*. The eggs of the *Chrysopa* were so abundant that often from twenty to thirty could be counted on a single small outer branch of a few inches in length, yet many of these had already hatched. The number of Lady-birds in all stages sent with this lot amounted to several hundred. The weather was unusually hot during two days of collecting, the thermometer registered 108° Fah. in the shade, and from one small box left in room over night, where the temperature had not been below 90° Fah., about

fifty of the flies issued during the night and early morning. They were crawling on the window at 6 a. m. Many more were found within the box, with wings not yet developed.

I returned again to Adelaide within four days, the time taken in making the trip. I wrote to the United States consular agent, Mr. George Harris, at Brisbane, Queensland, to ascertain for me the occurrence of *Icerya* in that district. Through the department of forestry at Adelaide I was informed that *Icerya* existed at Stansbury, on the Yorke Peninsula, at the place of Mr. F. Wurm. Accordingly a trip was made across the water on October 1, and I was kindly and hospitably received by Mr. Wurm. That gentleman showed me a small orange-tree completely covered with *Icerya*, but aside from this, not a single specimen could be found for miles around, nor had they ever been observed before this. The tree infested with the scales was completely covered with a small black ant, so much so that several could be counted upon each of the scales at the same time. Upon examination only two specimens of the *Icerya* were found to be parasitized by the *Lestophonus*, and these had already left. No doubt the abundance of the ants upon the scales prevented the flies from ovipositing. I recommended keeping the ants off the tree as the scales would then disappear.

How often must the mother flies have been hovering over this young tree in their attempt to lay eggs, and how many of them must have been carried off as food for the young of the industrious ants! Mr. Wurm also informed me that *Icerya* had been found by him upon the roots of black grass. On examination, however, this proved to be an entirely different coccid, *Lecanium oleæ*, which had found its way to this place in small colonies on olive-trees. The cut-worms had done considerable damage to fruit-trees, grape-vines, and other vegetation during November. Some of the apple-trees were completely stripped of their foliage. Melolonthid larvæ had been very injurious to the wheat crop by eating the roots.* The common grasshopper was also in abundance here.†

On December 6, from four large specimens of *Icerya* that had been inclosed, thirty-four flies (*Lestophonus*) and five parasites of the latter had issued. I examined condition of *Icerya* on place from which last sending was made, and from which nearly every one of the old and infested scales had been removed, the trees at the time being full of large *Iceryas*; yet at this date but very few of them were left, the coccinellid larvæ and the *Chrysopa* in conjunction doing good work, eating, no doubt, the healthy as well as the infested scales. Some of them had apparently gone through second molt, yet the greater part were

* Three species of Melolonthid beetles were collected at this point by Mr. Koebele, and being unknown to our fauna will have to be carefully studied for determination.
—C. V. R.

† The same undetermined species referred to on p. 17.

still in the first stage. Only very small larvæ of the *Lestophonus* were found within scales after first and second molts. Within a nearly full-grown specimen on trunk of lemon-tree, the only large one found there, two larvæ of the fly were nearly full-grown.

I left on December 10 for Melbourne, seeing that it was necessary to hunt up a new field. There I had hopes of gathering a sufficient quantity for a shipment. The largest colony I was able to discover at Melbourne existed in a church-yard on Collins street, upon small trees of *Pittosporum undulatum*. I could not find the proper person to apply to for admittance, and a policeman whom I consulted in regard to getting the tempting specimens advised me "not to jump from the fence as they surely would have me arrested."

I left them undisturbed and went in search of others. A few specimens existed in the gardens of the government buildings; an occasional specimen in the park adjoining the Exposition grounds; some on a hedge in front of a hotel, and single specimens were found on trees in a park at St. Kilda, while at the same place on a garden hedge quite a number were found; all these on *Pittosporum undulatum* and *P. (engenoides?)*. At the last-named place the lady-birds were found at work, and all were gathered later for shipment. I went east of Melbourne as far as Bairnsdale, yet no *Icerya* could be found. A strong attempt was made to find out the whereabouts of the Monophlebid of which Mr. Crawford had sent specimens to California. They could not be discovered in numbers in the woods, yet in the parks at St. Kilda I was soon rewarded by finding the insects looked for, viz.: *Monophlebus crawfordi* Maskell (Fig. 9), under loose bark of various Eucalypti, embedded in cottony matter, and the single, (often 2 inches) long, white, setous, anal hairs sticking out.* Only a few dozen of the monstrous scales, however, could be gathered in a hard day's work. Up in the tree-tops I often found a similar Monophlebid, only varying in color somewhat. It is as large, or even larger, than *M. crawfordi*, and sits fastened to the branches and exposed without any cottony attachments, although sometimes under chips of bark.

On my way home in the evening one of these scales came hurriedly running down on the trunk of a tree. So the next day, at the northern park at Melbourne, the ground at the base of the Eucalypti was examined. Here I found, sometimes lying loose on top and dead (in this case always destroyed by *Lestophonus*) and below ground to a depth of 3 inches, in a small cave nicely embedded in loose cottony matter if healthy, or generally mixed up with the ground if parasitized, large numbers of these scales. These, Mr. Coquillett informed me on my return to Los Angeles in April, gave the best results in *Lestophonus*, as these parasites were still issuing then, four months after they were col-

*Not mentioned in the description of *Monophlebus crawfordi*. See "On some New South Australian Coccidae," by W. M. Maskell. (From the Transactions of the Royal Society of South Australia 1888.)—A. K. •

lected. I have counted as many as sixty-two holes in one of these scales, showing what a number of parasites they are able to support. A third species of these large Coccids was found attached to the roots and base of Eucalyptus below ground, even larger than the two preceding. About forty specimens of these produced no parasites. One specimen, probably of this latter species, was found embedded under bark between the forks of a very large Eucalyptus about 8 feet from the ground. This measured fully 1 inch in length, and was about two-thirds as broad, being nearly round.

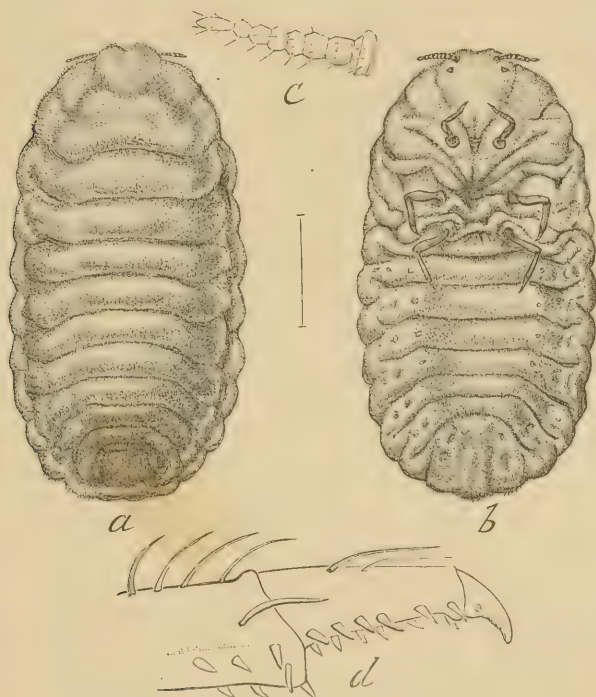


FIG. 9.—*Monophlebus crawfordi*: a, female from above; b, same from below—enlarged; c, antenna; d, tarsus of same—still more enlarged (original).

I left for Sydney on the 24th to place the insects in an ice-house previous to shipment. In the meantime a letter had been received from Brisbane stating that *Icerya* occurred there occasionally in numbers, and having had a letter from you in which you expressed the hope that I would be able to visit Mr. Carl H. Hartmann, a correspondent of yours at Toowoomba, who had found *Icerya* on his oranges in 1886, I started for Queensland on December 29 and arrived at Toowoomba early on January 1, 1889. During the same day a full-grown female *Icerya* was discovered in the woods about three miles from this place on *Acacia decurrens*. During a search of several hours no other specimens were found. I visited the Range nursery the following day and met the son and the brother of Mr. Hartmann, who himself had died from the effects

of fever contracted while on a scientific trip to New Guinea. I also met the man who had been employed at the time in 1886 when Mr. Hartmann received an illustration from Brisbane of *Icerya*, and directed him to look over the trees for specimens, when several scales were found. Since then, however, none have been found. While looking over the lemon and orange trees I found one single nearly full-grown specimen, but aside from this no trace of them. A peculiar Coccid resembling *Icerya* somewhat in structure was found on an apple-tree. The gentleman informed me that *Icerya* was always most noticeable in wet seasons, but that it never appeared in such numbers as to be injurious.

I found here in abundance the large hemipterous insect so destructive to the orange in Queensland and New South Wales. A second species somewhat smaller than this, yet equally mischievous, was found at Adelaide (Fig. 10). Trees were observed at this place with all the



FIG. 10.—*Mictis profana*—natural size (original).

fruit and most of the young shoots destroyed. Both species live and grow upon the sap of fruit and tender twigs.* *Aspidiotus aurantii* was present here in numbers and also *Lecanium oleæ*, both upon oranges; the latter, however, is kept well in check by a lepidopterous (Noctuid) larva, *Thalpochares cocciphaga*, Meyrick (Fig. 11).



FIG. 11.—*Thalpochares cocciphaga*—slightly enlarged (original).

Several young orange trees had been completely cleaned by larvae, and eight chrysalids were found upon a young plant. Mr. H. Hartmann also informed me that near Brisbane a dipterous larva existed which occasionally destroyed all the orange crops, and in 1886, which was a very wet season, a dipterous larva destroyed not only all the oranges but also nearly all the other fruits, even the apples and pears. He also gave me the following list as blight-proof apple-trees: "Northern Spy, Majetin, Irish Peach, Streaked Peach, Hartmann's Seedlings Nos. 1 and 5, New England Pigeon, Shepherd's Perfection, Chubb's Seedling, Canvade, Flushed Peach."

On January 5, having obtained free passes for the Queensland railways, I left Toowoomba for Brisbane. On my arrival at the hotel I met with specimens of *Icerya* on an ornamental plant in the passage-way. This and a few other specimens found in gardens through the city were all I could find, yet in damp seasons they occur sometimes in numbers, as I learned from several gentlemen acquainted with the insect.

Mr. Henry Tryon, assistant curator of the Museum, kindly introduced me to several persons in Brisbane. He himself was about to publish a

* The second of these insects is *Mictis profana* Fabr., and the other is a species of *Aspongopus*.—C. V. R.

paper on *Icearya* and its parasites, of which he has shown me a small Chalcid of which he bred several specimens from *Icearya* inclosed in paper box, saying it was a true parasite.* I bred this same insect from a few specimens of an *Icearya* sent to me by Dr. Bancroft, of Brisbane, as feeding upon mangrove tree (*Avicennia officinalis*, Linn.). This scale differs in coloration from the true *I. purchasi* and may prove to be a new species. Mr. Maskell, to whom the insect was shown, thinks it only a variety. It would be an interesting one, however, for of all the *I. purchasi* that I have seen, none show such a uniform bright yellow color. No specimens found on mangrove at Auckland show such bright yellow color. Mr. Tryon is of the opinion that *Icearya* originated in China, from the fact that nearly all specimens he found at Brisbane were upon plants from that country. Dr. Bancroft, in his paper on Coccidae (Philosophical Society of Queensland, vol. 1, August, 1869), referred to the then undescribed *Icearya*, and at that time, as he assured me, he had been acquainted with the insect for several years. The doctor further mentioned the occurrence of a scale on the sugar-cane in Queensland living on the roots of the young plants, and as these became larger, behind the leaves. It had been imported with the canes from Mauritius. He promised to secure specimens for me. No doubt this will prove to be *I. sacchari*.†

In the woods around Brisbane but few Coccids were found during my brief stay. The white waxy scale (*Ceroplastes*) so abundant on various plants in cultivation was here observed in large numbers upon a small shrub. Of the *Monophlebus*, which I had been informed was almost always numerous around Brisbane, only an occasional specimen could be found. Everything was so extremely dry that I gave up my intended trip by steamer further north, and as there was little prospect of obtaining sufficient material for a shipment at this place, I returned slowly towards Melbourne, making occasional stops along the road, yet without discovering any *Icearya*. At Melbourne I was fortunate in finding many more of the *Monophlebus*. On a few trees, under the bark, they occurred by the dozens, often many together, but they were all dried up and the flies had left sometime previous. Those in ground were still in good condition. A large number of them had deposited their eggs and were shriveled up, yet during the two days a fair number were found parasitized. At Sydney, January 21 to 23, a number of *Icearyas* with parasites, and probably two hundred or more of the Lady-birds in all

* Mr. Tryon has recently published in a pamphlet entitled "Report on Insect and Fungus Pests, No. 1," a general description of this parasite, but without attempt to name or properly place it. From the description it seems to be identical with a true parasite of *Icearya*, which we have received from Mr. Crawford, and which we have characterized, since the above was in type, as *Ophelosia crawfordi*, n. g., n. sp.—C. V. R.

† We find among Mr. Koebele's Brisbane material a small Coccinellid not here referred to, but which is labeled "feeding on *Icearya*." It may be the species referred to in the following paragraph, as found at Sydney, and must remain for the present undetermined.—C. V. R.

stages, were collected, most of them in the Town Hall garden. I found here also feeding upon the Scales a few specimens of a small *Scymnus* in all its stages which were inclosed. The first brood of *Icerya* in warm and exposed places at Sydney had by this time become nearly grown, some of them beginning to exude cottony matter, while others in more secluded spots were quite small. The isolated acacia tree, so full of *Icerya* in September, had become entirely clear, nothing but a few old and torn egg-masses being visible. With this I finished collecting the parasites and enemies of *Icerya* in Australia, as from letters received from Mr. Crawford, at Adelaide, dated January 11 and 12, there was little hope of obtaining sufficient material at that place for another consignment, nor would it have paid to search for *Monophlabus* in the ground, as at the time they could not be found in large numbers in the woods. Moreover, many of their parasites had already left, while the *Icerya* still known to me at Melbourne and Sydney were not sufficient to make a good shipment.

A letter received at this time from you in which you directed me to visit New Zealand and study *Icerya* there until the arrival of the next steamer for San Francisco, in case the exposition commission would pay expenses, was shown to Hon. Frank McCoppin, who at once consented to my proposed trip. I therefore left Sydney on the steamer of January 23 with some hope of clearing up the mysterious disappearance of *Icerya* in New Zealand. Arrived at Auckland on the 28th, the Scales with parasites and Lady-birds were repacked from tin into wooden boxes, and were found in excellent condition. Everything within the tin boxes had the appearance of being placed there only a few hours previous. There was no indication of any mold. Some fresh *Iceryas* found in a private garden at Auckland, on *Acacia decurrens*, were inclosed as food for the Lady-bird larvæ. These latter Scales were in a small colony all close together on a few small branches, and numbered about eight hundred specimens. No insects preying upon them were found. At the United States consulate a letter was found awaiting me from Mr. R. Allan Wight, dated October 10, 1888, in which the writer mentioned various localities infested with *Icerya*, wishing me to visit Hawke's Bay, at Napier, where the Scales were still numerous, although fast disappearing, and where a good field for observation would be open. I therefore left Auckland on January 30, overland, the New Zealand Government, through our consul, having furnished me with a free pass for four months. On this trip not many observations could be made.

The Cabbage Aphis was found in large numbers all over the northern island of New Zealand as well as in Australia. A Coccinellid was found subsequently at Napier feeding upon this Aphis in large numbers. It is described by Mr. W. Colenso as *C. nora zealandica* (Fig. 12). About fifty specimens of these were collected and placed in empty pill-boxes. Of these twenty-one were still living on my arrival at Alameda, where they were liberated. A second species was found feeding upon the Aphis in

small numbers; this is *C. tasmanii* (Fig. 13). The Cabbage Plutella (*Plutella cruciferarum* Zell.) was here as well as all over Australia, observed to be very abundant. Mr. French, of Melbourne, had a specimen on exhibition with the name of "*Plusia crucifera*" as injurious to cabbage. The small Tineid, so destructive to potatoes in California, and no doubt already distributed over the most of the Western States, has been known in New Zealand for years, and it is doing the same mischief all over Australia, where it originated. In conversation with a merchant from Denver, Colo., recently, he said that a year ago he received three car-loads of California potatoes, infested with these worms to such a degree that they could not be sold. I also met here, wherever apples are grown, with what is probably *Mytilaspis pomorum* Bouché, the species previously referred to as such.

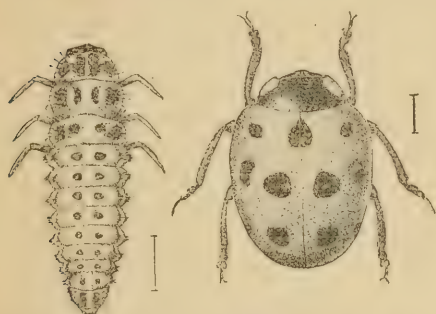


FIG. 12.—*Coccinella nova-zealandica*, larva and adult—enlarged (original).



FIG. 13.—*Coccinella tasmanii*, adult—enlarged (original).

Mr. A. Hamilton, curator of the museum at Napier, who had been informed by Mr. Wight of my intended trip, awaited me and at once showed me a number of infested Acacia trees. *Icerya* was here still in countless numbers. Before breakfast the next morning this gentleman showed me one of the Australian Lady-birds,* saying that he found it among *Icerya*. On investigation they were found in large numbers in every place visited at Napier and several miles out in the country. I left Napier for Wellington on the 11th to visit Mr. Maskell. This gentleman had never had the opportunity of studying the enemies of *Icerya*, as the scales are not found anywhere within 80 miles of Wellington. It had been the firm belief of some persons in New Zealand that certain Ichneumonids were the destroyers of the Scales. I saw dozens of several species of these upon one orange tree infested with *Icerya* near Napier, not injuring them in any way, but devouring the sweet exudation from them. Larger numbers of flies were present than Ichneumonidae, and even Crambidae were engaged in the same performance, yet these received no share in the compliments. Mr. Maskell had received from the Cape of Good Hope about two hundred specimens of several species of Coccinellids, which, as the sender informed him,

* *Vedalia cardinalis* Muls.—C. V. R.

were all preying upon *Icerya*. They were sent to Nelson and placed under tent with the Scales. A few days later, however, the wind took away the tent and nothing more has been seen since of the Coccinellids. Several species of these beetles which Mr. Maskell kindly presented me with were left with you at Washington. Amongst them I could not find the *Rodolia iceryæ*, Janson (Fig. 14), which is destroying the Scales at the Cape and, with the possible exception of one species, I do not think they will feed upon *Icerya*.



FIG. 14.—*Rodolia iceryæ*.
—enlarged (after
Riley).

My time was too short to visit Nelson, and Mr. Maskell kindly promised to secure for me a box full of scales from that district, so as to enable me to find out whether some parasites or enemies existed there. This box was sent to me on board the steamer at Auckland and, on opening the same, several flies were found that had issued en route. Only one of them was in perfect condition; all the others were crippled. They had crawled in among the paper used in making up the parcel. No other specimens were bred and no holes were observed in the scales, so the only possibility remains in the larva of this fly being predaceous upon the eggs of *Icerya*. Apart from these flies no other insects were observed from the Nelson Scales. On my return to Napier I got at once to work gathering the Coccinellids in all stages. They were in such numbers that I found it not very difficult to collect here about six thousand specimens during the three days (February 14 to 16). As many as eight eggs of the Lady-bird were observed on the upper side of the female *Icerya* just beginning to exude cottony matter. Opposite to this on the small branch of *Acacia*, five young larvæ of the Lady-bird were feeding on the under side of a half-grown scale; in one instance even nine Coccinellid larvæ were found attached to a small



FIG. 15.—*Scymnus fagus*—en-
larged (original).

Icerya. The mature beetles were not numerous, but every branch full of scales had a greater or less number of eggs and larvæ. The eggs are chiefly deposited among the vigorous half-grown scales. Here the largest number of the eggs and young larvæ were found. They are generally single, thrust in between the scales and fastened onto the branch, on the scale itself, and often on the under side of the scale, as the mother Lady-bird will sometimes raise the *Icerya* with her hind legs and thrust the egg under it. At times two or more are found together, always lying flat and in irregular position. Aside from this valuable Coccinellid, a small *Scymnus* was observed here feeding upon the scales, but in small numbers only. This was named for me later by Captain Broun, as *Scymnus fagus* (Fig. 15).

I left Napier with my valuable lot of Lady-birds on the 17th. They

were placed in the ice-house on the steamer, and as soon as Auckland was reached I went to the freezing-house and there my Coccinellids were placed in a cool room with a temperature of 38° Fah. Having been informed that *Iceryas* had been very numerous almost a year ago at a gentleman's place near Lake Togabuna, several miles out of Auckland, a trip was made as soon as my Lady-birds were safe, for I was very anxious to get at the fact as to what had destroyed the Scales around Auckland, and if it were not the same insect found at Napier. I was shown a couple of *Acacia* trees, one of which had been destroyed by the Scales, and a second, still living, which had many *Iceryas* upon it. All the Scales on this small tree were examined, and, with the exception of a small Coleopterous larva within one of the egg-masses, no enemies could be observed. Both these trees were growing among old pine trees and were much shaded by them, in fact so much so that no sun-loving insect like the Lady-bird would venture into them. Close by about a dozen orange trees were growing in an open field, and on my inquiring if no Scales were upon these trees, the gentleman remarked that only about nine months since they were full of them, but that all had disappeared. These I wanted to see, and on the first tree reached, while yet at some distance, I could see, exposed to the sun on the upper side of a leaf, a black glistening spot, which was the insect looked for, the Australian Lady-bird. On this tree more Coccinellids than *Iceryas* were found. The Lady-birds, if not at rest on top of a leaf in the hot sun, were busily running or flying about. This is an interesting fact. All the orange trees in the open field were completely cleaned of the thousands of Scales by the Coccinellids, while closely adjoining, among the dark and shady pines (*Pinus insignis* Douglas), a large *Acacia* tree (*Acacia decurrens*) was destroyed by the Scales, even the adjoining branches of the pine trees being dead, and, as stated by the proprietor, from the effects of *Icerya*.

As yet the scales have not been observed to my knowledge on pine trees in California, yet Mr. Maskell also told me of having seen pine trees loaded with them. I observed here also an *Aspidiotus* very injurious to apple trees. The following day the place visited on my first arrival in Auckland was examined again, but only a few large females could be found. The young were just hatching, and many eggs were still present. Mr. Cheeseman had been informed by Mr. Purchas and others that *Icerya* existed abundantly in the woods at the English church cemetery (Paeroa), infesting *Sophora tetraptera*. He kindly accompanied me to the place, and before long pointed out the tree, which is closely related to the *Acacias*. We soon succeeded in finding the scales in large numbers on a few of the trees, when a careful investigation was made and a few specimens of the small *Scymnus fagus* were found. A small hemipterous insect was present among the egg-masses in all stages, the young being found within them, and two species of small spiders had built their houses among the egg-masses

also. From the many remains of the young *Iceryas* it was evident that they fed also on these. The Australian Coccinellid had not yet discovered this colony of scales, yet it must have existed here in numbers for at least four years. Only a few scattered specimens were found on other shrubs, but they had spread to the Mangrove bushes growing close by in large numbers. On this plant they thrive remarkably well.

Captain Broun, at Drury, the authority on New Zealand Coleoptera, was visited and asked in regard to the Australian Lady-bird. He did not know the insect, nor had he ever met with it, but he had the small *Seymnus fagus*, which seems to be more widely spread and lives upon various Scales; neither had he met with the common *C. nora-zealandica* which I found at Napier. During a ramble in the woods with the captain I found a large Coccinellid in all stages feeding upon *Ulenochiton viridis* Maskell infesting *Coprosma lucida*. This Coccinellid was identified by him as *Leis antipodum* Mulsant (Fig. 16). Upon the same tree was also found in abundance a second and smaller Scale of the same genus; this is *C. perforatus*. The captain kindly promised to send me a number of living specimens of the Coccinellid, and he kept his promise, though, unfortunately, the insect had become so rare that with assistance he was able to find only six specimens. These came in an ice-chamber well packed in a large box, but only one of them was living on arrival here.



FIG. 16.—*Leis antipodum*, two varieties—enlarged (original.)

On February 25 the steamer was ready to sail. Having made arrangements with the butcher on board the previous day as to the most convenient time of receiving my insects into the ice-house, they were transferred from the freezing-house on board the steamer, which did not take more than ten minutes, and the insects were not disturbed in their dormant stage during the time. Every day on the voyage I received the answer from the butcher, to my inquiries about the parcel, "Your bugs are all right." On March 10, after leaving Honolulu, one of the boxes with the Lady-bird larvæ was examined and found in excellent condition; no dead larvæ could be found among them, and this was twenty-four days after the first were collected. On Saturday evening, March 16, we arrived at San Francisco, too late to have the insects forwarded, and I could not send them off before Monday evening, March 18. They were probably received and opened by Mr. Coquillett two days later. This would make, thirty-four days that they were in-

closed, and yet they arrived in excellent condition, better than any previously received. Having been on ice for twenty-nine days, no doubt many of the eggs arrived here before hatching, and the larvæ under such conditions would make little progress in their growth.

As will be seen from these notes (and such is my firm belief), *Icerya* is indigenous to Australia, having spread from that country to the Cape of Good Hope, New Zealand, and our continent, and no doubt with some plants brought here. The pursers on steamers running between San Francisco and Sydney informed me that with every trip a greater or less number of plants are brought over. On these no one would notice *Icerya*; even an expert would overlook a few of the tiny young scales if not especially searching for them. At the time *Icerya* was first observed here many oranges were brought over. Mr. Sutton, of the Alameda, informed me that in 1873 the entire market in San Francisco was supplied with Australian oranges. All this matters little. We have the pest, and now the most effective enemies of it. Before long the work of the latter will be appreciated all over the State. At this date small colonies of the Lady-birds have been established in almost every district infested with *Icerya*, and at Los Angeles they must be present already by the thousands.

It was difficult in Australia to ascertain which was the most effective enemy of *Icerya*, on account of the scarcity of the latter insect during the unusually dry season of my visit. It is safe to say, however, that the Lestophonids are always and at any time ready for any *Icerya*, since they breed upon so many and varied Scales infesting the Eucalypti and Acacias, of which the Australian woods chiefly consist. Often *Icerya* will appear in large numbers in some private garden in a city, and yet, as I have been informed, they will be out of sight in a short time again. This entire clearing up is the work of the Lady-birds, for in most cases the infested scales will produce eggs, and the flies are never able to entirely clear a tree of them, in which case the Lady-bird steps in and devours Scales, flies, and all. It is only in such protected places that the scales sometimes become numerous, as it takes time for their enemies to establish themselves. The *Lestophonus* no doubt would in time increase here so as to keep the *Icerya* in check, but this would be years, for only two broods of it were observed in Australia, as many as that of its host, the *Icerya*, the parasite appearing about the same time as the young of the latter. I have seen about eight species of Monophlebidae upon which *Lestophonus* will undoubtedly breed.

Dr. Diez, of the Adelaide Museum, has shown me several specimens of a species of these scales, which he assures me were fully 2 inches in length when received alive from the interior of South Australia. He had written to the party who sent them for information regarding the monstrous scale-bug, yet the only light he received upon the subject was that the discoverer of the Scale was found dead in the bush near

Baroota, and he assumes that they came from that district. Such a large Coccid would be able to support several hundred of the *Lestophonus*. I have also bred this fly from a species of *Calostoma* found on a shrub at Mount Lofty, South Australia, where two specimens of *Iceya* were found, both invested by *Lestophonus* on a species of *Acacia*. In California we have to my knowledge no Scales upon which this fly would breed, with the exception of *Pulvinaria* and *Dactylopius*. Of the latter there are many species found almost everywhere; a large species almost equal in size to *Iceya* exists upon our Redwood trees (*Sequoia*). This no doubt will in time be attacked by the flies. I have not the least doubt that in time this *Lestophonus* will do effective work upon *Iceya* even if slow (too slow for the Americans, as Mr. Wolfskill remarked). So far I have seen little progress of it. On my visit to Los Angeles (April 12), it seemed that very few remained of the vast number of flies received here in good condition. All had been placed under one tent, erected over a tree for the purpose of propagating, instead of forming a new colony with every consignment received; yet it is to be hoped that very many of the flies have escaped from the tent.

As far as the Lady-bird is concerned it will show itself, or rather has done so already. They never were found by the writer except feeding upon *Iceya*, and yet there must surely exist in Australia some other scales upon which they feed. The work this little insect is able to accomplish is shown by the fact that by chance it went over to Auckland, New Zealand, where the *Iceya* was in a flourishing state, having destroyed nearly everything about five years or so since, and there cleared nearly the whole district around Auckland within about two years. From here it has spread south as far as Hawk's Bay without any artificial help, everywhere increasing in numbers as long as the food would last. I shall be greatly mistaken if this one insect alone is not master of the situation within two years' time, although we have comparatively few to battle with. It will need thousands everywhere to clean up the millions of scales. I have no time while in the field to study much of the life-history of this valuable insect. My first motto was always "get as many as possible." If once established here, the life history may be studied at leisure.

I will, however, relate part of the doings of one pair of these insects. On February 9 a few beetles and pupæ were collected in a glass jar. Two male Lady-birds were noticed running and pushing around one of the pupæ in which one of the female Lady-birds had just issued and was within the case with soft and tender wings and about helpless. Soon the male succeeded in pushing her out, and immediately after this had been accomplished, one of them united with her at about 3 p. m. This pair were placed in a small wooden box and they remained in copula until the following morning at 7. They were left in this box until February 17, when they were placed in a large jar with twigs of *Acacia* full of *Iceyas*. No eggs were observed in the box, which was completely

clean, with the exception of the numerous red spots produced by the Lady-bird, for they had subsisted on their own eggs during their confinement. As soon as the female Lady-bird was among the scales she became quiet, stopped, and deposited an egg upon the twig. As soon as this was done she turned around and devoured the same, which took her about a half a minute. A few moments were spent in cleaning herself and then another egg was brought forth and eaten. After this and another wash she attacked and devoured a half grown scale. This was eaten into from the back, very quietly at first, yet in a little time she became lively, almost furious, tearing the scale off from its hold by the beak and turning it up and down in the air with the mouth-parts, assisting in this with the anterior legs. In about one minute this was devoured and nothing but the empty skin left, after which she went to work, business-like, and deposited eggs quietly, sitting at rest upon the scales, and every few minutes thrusting an egg in between or generally under them. A very large scale was lifted with the posterior legs and the egg thrust beneath. All the strong attempts at love affairs by the lively and not hungry male were resisted. I was careful to see that twigs with nothing but *Icerya* on them were selected for food; at least no young larvæ could be observed on them; yet the second day after the *Coccinellids* were placed in with them, young larvæ were seen, and they came out so fast that within a few days my jar was a living mass of them.

On February 22 a few of the larvæ were full grown and settled down in a quiet place, fastening the ends of their bodies down with a thick and sticky substance and remaining in this way, becoming shorter and stouter, for four days. On the 25th the first pupa was observed; from this the mature beetle hatched in the evening of the 28th. Another appeared the following day. Again, on March 3, a pair of the bred Lady-birds were placed together, with clean food, and the next day, March 4, eggs were observed which hatched on the 8th. This I could not carry through, as the food began to dry up; in fact, on March 18, many grown and hungry larvæ were devouring each other in this jar, and even the mother of them, which was still living, was noticed devouring one of her young, a larva. Three times, at intervals, this pair were observed in copulation. Eleven beetles of this last brood reached maturity, having had nothing to feed upon but one supply of scales that had already been boxed up for eight days, the beetles having been born and forced to live upon one another. Taking four days for the eggs to hatch, about eight days for the larvæ to grow, three days until pupating, and four days more for the pupa to emerge, this would only make nineteen days from the egg to the mature insect, providing the weather is warm. No doubt we will see cases where, in less time than this, all the stages are gone through at Los Angeles in hot weather, and we may expect at least fifteen broods annually of this insect to two of *Icerya*.

Another most important insect is the moth *Thalpochares cocciphaga* Meyrick. It is greatly to be hoped that this insect will be introduced here. I have been able to get about a hundred larvæ here in good condition, yet what became of them I am not able to state as yet. The insect is apparently easy to breed. Five of the larvæ were placed in a pill-box in the field during January and overlooked. During April, on opening the box at Alameda, I found that four of the moths had issued, copulated, and deposited many eggs. The young larvæ, however, had already left the box and no trace of them could be found. It would have been easy with the number received here, had a little care been bestowed upon them, to breed and introduce them upon most any of our larger Scales.

The *Chrysopa*, of which eggs and larvæ were sent over with every shipment, excepting the last, have been successfully introduced. In April, while in Los Angeles, several of the insects were noticed upon orange trees in Mr. Wolfskill's orchard.

Several species of *Seymnus*, about six in number, that were sent, all live upon *Coccideæ*. The largest of them was abundant in Brisbane upon various soft scales, and was also found at this place upon *Icerya*.

Mr. Webster brought to me from Tasmania a box full of Eucalyptus twigs with *Eriococcus eucalypti*, the *Seymnus* so numerous at Melbourne, and sent here in numbers, together with two small moths, a Pyralid and a Tineid, which were feeding upon the *Eriococcus*.* These, as all other insects, were turned over to Mr. Coquillett. Various other beneficial insects were observed during my four months' work in Australia, all of which if introduced here would be of great value. One of these deserves to be mentioned. It is one of the largest Lady-birds, and had cleaned whole apple orchards of the Woolly Aphis in South Australia and Victoria. They were also observed to feed upon *Lecanium*.

All material collected and studied in Australia relating to this subject and otherwise of importance will be mounted and sent to you with the notes thereon.

* These moths we have no means of now determining, even if described. The Tineid much resembles *Eucleremisia bassettella* of this country, and the other is a Phycid near *Dakrura*.—C. V. R.

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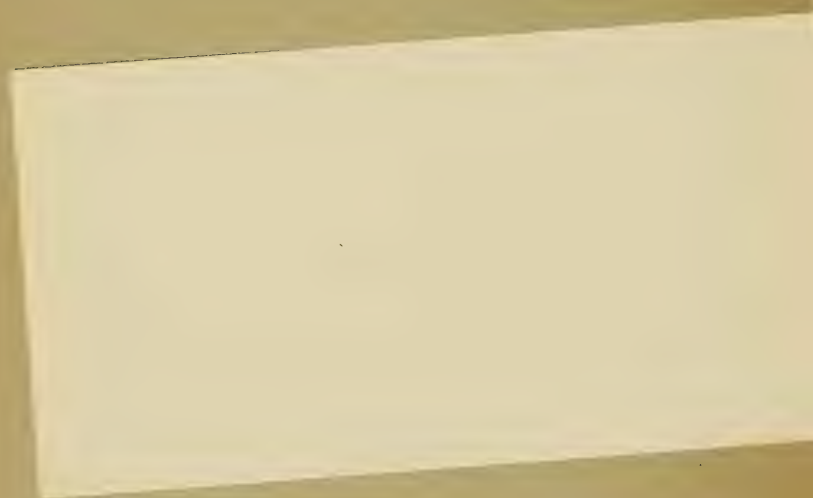
R E P O R T
OF A
TRIP TO AUSTRALIA
MADE UNDER DIRECTION OF THE ENTOMOLOGIST
TO INVESTIGATE THE
NATURAL ENEMIES OF THE FLUTED SCALE.

BY
ALBERT KOEBELE.

(PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.)



WASHINGTON:
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1890.



U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 21.

(Revised Edition.)

R E P O R T

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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY,

Washington, D. C., November 22, 1889.

SIR: I have the honor to submit for publication Bulletin No. 21 of this Division, being the report of Mr. Albert Koebele upon the Fluted Scale (*Icerya purchasi* Maskell) and its natural enemies in Australia. I had intended to incorporate it in my forthcoming annual report, but the limited space allotted to that report makes it necessary to publish this as a separate bulletin.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The following report by Mr. Albert Koebele, one of the California agents of the Division of Entomology, gives an account of his trip to Australia, made during the late summer and fall of 1888 and the winter of 1888-'89, under instructions from this Department, for the purpose of investigating the Australian natural enemies of the Fluted Scale (*Icerya purchasi* Maskell) with a view to introducing the most efficient of them into California.

Failing to secure a specific appropriation from Congress for this purpose, although assisted in the attempt by the California delegation, and particularly by the Hon. C. M. Felton, and failing also to secure the removal of the clause restricting travel to the limits of the United States, we were led to accomplish the result through the kindness of the Department of State, in connection with the Melbourne Exposition, an arrangement having been made whereby two of the salaried agents of the Division should be temporarily attached to the Commission, their expenses, outside the United States, to be defrayed by the Commission, within the sum of \$2,000. The warm thanks of this Department are due to the Department of State for this coöperation, and particularly to the Hon. Frank McCoppin, commissioner-general to the Exposition, to whom the matter was submitted by the State Department for approval. Mr. McCoppin at once accepted the proposition, and upon Mr. Koebele's arrival in Australia helped him in every way possible to make the experiment successful.

Mr. Koebele was sent, as just stated, for the specific purpose of studying and importing the natural enemies of the Fluted Scale, while the other agent, Mr. F. M. Webster, was sent to make a special report to the Commission on the agricultural features of the Exposition. Mr. Webster's report has been sent to the Commission, and was formally submitted to Mr. McCoppin. A copy of the present report, although purely entomological, and having little relation to the Exposition proper, has also been transmitted to Mr. McCoppin, as the results of the mission are, and ever will be, connected with his exposition work.

While a number of other entomological matters are referred to in the report, Mr. Koebele never lost sight of the main object of his mission. How successful it has proved late reports already published in INSECT

LIFE, and elsewhere, have abundantly testified. They have more than justified the anticipations expressed in my last annual report:

We fully expect to learn of the increase and rapid spread of this new introduction as well as some of the other predaceous species which have been introduced, and to find that in a comparatively few years the orange groves of southern California will be kept measurably freed of the pernicious Fluted Scale without so great an effort on the part of the growers or so great expense in destroying it. That nature will, with the new conditions induced by these importations, come to the relief of the fruit-grower, and that this interesting experiment will result in the ultimate saving of untold millions to the people of the Pacific Coast is our sincere belief which we hope to see verified. Not that we expect the *Icerya* to be ever entirely exterminated; but it will be kept under subjection so as to be comparatively harmless, as it is in its native country.

One of the insects imported, viz, the Cardinal Vedula (*Vedula cardinalis* Mulsant), has multiplied and increased to such an extent as to rid many of the orange groves from *Icerya* and to promise immunity in the near future for the entire State of California. In fact, the rapid multiplication and the effective work of this little beetle are almost incomprehensible until we come to consider its power of increase in a climate like that of southern California, where there is scarcely any cessation in its activities.

A careful account of the transformations of the Vedula has been prepared by Mr. Coquillett and was published in INSECT LIFE for September, 1889, pages 70 to 74. I reproduce the figures in connection with Mr. Koebele's report in order to familiarize those who have not yet seen it with its appearance. I have also had some other figures made to accompany the report.

The period from the laying of the eggs until the adults again appear occupies less than thirty days for the Vedula. At this rate of increase, calculating that three hundred eggs are laid by each female, and that one half of these produce females, it will readily be seen that in six months the offspring of a single female beetle may under favorable circumstances amount to over twenty-two trillions. So far it has not been noticed to prey upon any other insect than the Fluted Scale, a fact which accounts somewhat for its exceptionally rapid work and renders the outlook extremely encouraging.

Of the other enemies of the *Icerya* referred to and more particularly mentioned in the latter part of Mr. Koebele's report, none of them have so far given much promise, and there is risk of their not being colonized by virtue of the extraordinary spread and increase of the Vedula, which has swept away from whole regions the Fluted Scale, upon which they depend. This contingency should have been avoided and I very much regret that they have not become established in California, because their establishment, and especially that of the little Dipteron, *Cryptochaetum iceryae*, would have helped in the general subjection of the pest and would be particularly valuable whenever the Vedula, for whatever reason, at any time practically forsakes a given locality.

Where possible I have endeavored by foot-notes to add to the specific accuracy of the insects referred to.

LETTER OF SUBMITTAL.

ALAMEDA, CAL., July 7, 1889.

SIR: I herewith submit my report upon the study of *Icerya purchasi* in Australia and New Zealand and the introduction of its parasites and enemies into California, undertaken under your direction and in accordance with your letter of instructions.*

Respectfully yours,

ALBERT KOEBELE,
Special Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

*The following is extracted from the letter of instructions:

WASHINGTON, July 3, 1888.

* * * As you are already aware you are sent to Australia for the purpose of making an investigation of the parasites and other natural enemies of *Icerya purchasi* with a view of introducing them into California. It will be necessary for you to go to Adelaide to see Mr. Frazer S. Crawford, who sent over the first Dipterous parasites and the *Calostomas* (or rather *Monophlabus crawfordi*). This Dipterous parasite has been named by Dr. Willsiton *Lestophonus icerya*, and at Adelaide you will probably be able to study this insect carefully. Make the most careful investigations where you can learn of the occurrence of *Icerya* and find all of its natural enemies in Australia. Find out also the periods at which these parasites oviposit and ascertain the season at which success in importation will be most likely with each and all of them. Once on the ground you can see for yourself just what will be necessary to be done in order to bring about this result. You should also endeavor to place the Department in correspondence with as many observers as you can interest in the subject, and should by all means endeavor to get at least one man who will be able to devote some time to the matter and continue observations after you leave. It is barely possible that we may be able to re-imburse some such person for the time expended, but for this I will write you later, if indeed I do not see you personally in Australia in November. You will, of course, inquire immediately upon arriving in Melbourne concerning the largest orange-growing districts in Australia, and also make inquiries as to the best places for observing *Icerya*, aside from Adelaide. If you will visit the Botanic Gardens in Melbourne you will be able to get some information there. Baron von Mueller, formerly director of the Botanic Gardens, is still a resident of that city and you will find him a very well-informed person to consult. I inclose you letters of introduction both to Mr. Crawford and Baron von Mueller. * * *

On this trip your salary will be paid as usual by this Department, but your expenses by the Department of State through Mr. McCoppin. * * *

REPORT OF THE FLUTED SCALE OF THE ORANGE AND ITS NATURAL ENEMIES IN AUSTRALIA.

By ALBERT KOEBELE.

In accordance with the commission received from the Hon. Norman J. Colman, United States Commissioner of Agriculture, and your letter of July 3, 1888, I left San Francisco on August 25, and arrived at Auckland, New Zealand, on September 14, where some hours were spent in getting information in regard to *Icerya*. I visited Mr. W. Will, editor of the *New Zealand Herald* and *Auckland Weekly News*, who then, and subsequently on my later visit, gave me valuable information in regard to the occurrence and disappearance of *Icerya* in the Auckland districts, as well as many other points of interest in horticulture; and also Mr. T. F. Cheeseman, curator of the Auckland Museum, who readily accompanied me to a place full of *Albizzia* (*Acacia*) *lophantha*, Bentham, which had been about three years previously completely covered with *Icerya*. I made a careful search for specimens on these trees, yet only four full-grown females with large egg-sacs could be found. On one of the scales two rather large mites were feeding, attached to the under side; and the masses of old and moldy remains of *Icerya* were still visible on the trunks of trees.

A residence on which formerly were many orange trees was also visited. There all of the trees had been cut down on account of the numerous scales, and at the time of my visit no *Icerya* could be found and none were observed during the year as the proprietors informed me. No one was able to state the exact reason of the disappearance of the scales; some disease was the supposed cause.

The steamer left Auckland the following day and arrived in Sydney, New South Wales, September 20. I remained there for four days in search of *Icerya*. On my first walk a number of them were discovered at the town hall premises, infesting a *Pittosporum* (*P. undulatum*), and the succeeding days a few more were found in one of the public parks, also on this *Pittosporum*. A large isolated acacia tree full of the scales was found in front of a private house in the eastern part of Sydney; all were full-grown females with more or less developed egg-sacs and ap-

parently in a healthy condition. As the trees infested were all inclosed, no proper examination could be made and the few obtained at the town hall showed no trace of parasites. A trip was also made to Parramatta, about 14 miles to the west of Sydney, to look into some of the orange orchards. I found nearly all the trees badly infested with the red-scale (*Aspidiotus aurantii* Maskell, Fig. 1), and still worse with what I con-

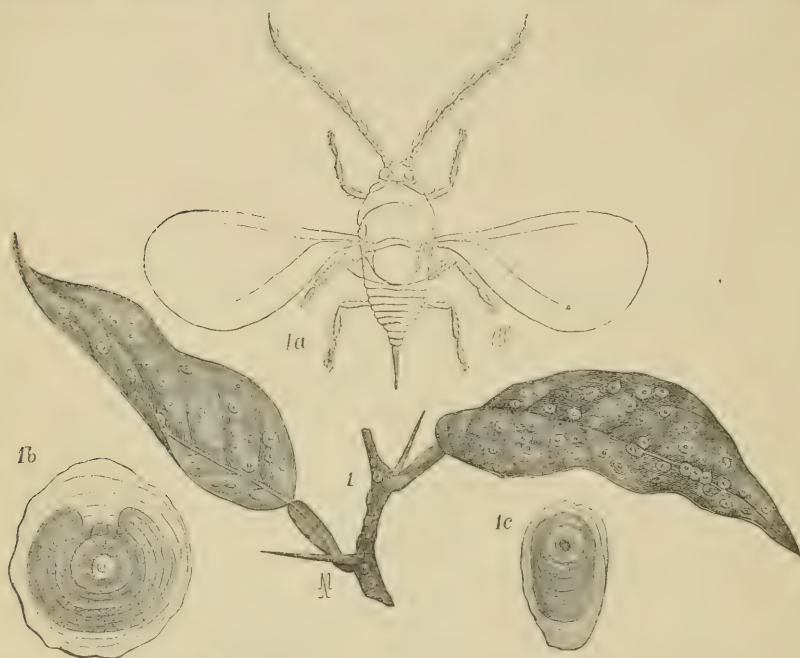


Fig. 1.—*Aspidiotus aurantii* Maskell: 1, scales on leaf of orange, natural size; 1a, adult male; 1b, scales of female; 1c, scale of male—enlarged (after Comstock).

sidered to be *Mytilaspis gloverii* Packard.* Indeed, some of the trees are completely covered by this latter scale, having the appearance of an old coat of whitewash on the bark which had partly fallen off. None of the several orange-growers there visited had ever seen an *Icerya* or was familiar with the insect. I left Sydney on the 24th and arrived in Melbourne the following day, having in the meantime, through the kindness of the United States consul, obtained a free pass over the New South Wales Railway, which courtesy was shown me by all the colonies subsequently visited. Indeed, I can not speak too highly of the kindness shown me by all the Government officials, and of the interest they took in the successful execution of my work. I remained in Melbourne for six days, during which time I visited Baron Ferdinand von Mueller, to whom you had given me letters of introduction. This gentleman assured me that the *Icerya* never became extensively injurious in Aus-

*A careful study of the pygidial characters of this scale shows it to be much nearer *M. pomorum* than *M. gloverii*. It seems, however, to be distinct from the former and will probably prove to be new.

tralia. Occasionally and in certain spots they became numerous, but always disappeared again. I also met Mr. C. French, Baron von Mueller's assistant, who has had some experience in entomology. He claims that the scale has been known to him for thirty-four years, yet he has never seen it in large numbers.

At the Zoological Gardens I found on a species of *Eucalyptus* a coccid in such numbers as to cover the under side of all the larger branches and the stem in part. Many of the winged males were secreted among the crevices of bark, with their two long white setous hairs protruding. Numerous larvæ of a coleopter were found under chips of bark feeding upon the scales, apparently belonging to some clerid. I never met with these larvæ again in my later researches nor with the coccid mentioned. A great variety of scales was observed at Melbourne; the most pernicious amongst them, a species of *Aspidiotus*, deserved attention. This is *A. rossi* Crawford, figured on his plate 18 of the Coccidæ, but as yet no description has appeared to my knowledge. I have seen olive trees completely covered by this scale; it will attack almost any kind of tree or shrub as I later observed. Many of the shrubs in the Botanical Gardens in Melbourne infested by this scale were in a dying condition. The introduction of this pest would be of serious consequence to the United States and we should be on our guard against this as well as a second species of waxy scale, probably a species of *Ceroplastes*. This last is covered by a thick, smooth, white, waxy matter which effectually protects it. Nothing would destroy this scale, except remedies against the newly hatched larvæ, which, before they exude any wax, are easily killed. The insect was observed all over eastern Australia, and it was numerous in the Botanical Garden at Sydney and in the woods near Brisbane. At the Botanical Gardens they could find no remedy except cutting down the infested plants. I recommended a strong resin wash for the newly hatched larvæ. No *Icerya* could be found during my short stay at Melbourne.

I arrived at Adelaide, South Australia, on October 2, with letters of introduction to Mr. Frazer S. Crawford, of the surveyor general's office, who received me very kindly and promised me his assistance, which promise he honorably fulfilled throughout my stay in Adelaide. I saw the man who discovered the parasites of *Icerya* (*Lestophonus iceryæ*), and, indeed, felt very happy when he promised to show me a large colony of the scales on the following day. Early the next morning Mr. A. Molineux, agricultural editor of the *South Australian Register and Adelaide Observer*, and proprietor of the *Garden and Field*, showed me about a dozen orange and lemon trees in a private garden in the suburbs of Adelaide all more or less infested with *Icerya*, and had been so for the previous two years. The scales were nearly all full grown, or rather nearly all of them had begun to exude cottony matter and deposit eggs, yet they were not quite so far advanced as those observed at Sydney.

The very first scale examined contained nine pupæ of the parasitic fly, *Lestophonus*, and the scale was still living. Nearly all of the many

others examined proved to have either larvæ or puparia within them; none of the flies had at that time made their appearance. I attended the gardeners' meeting at Adelaide on October 6, in order to get information as to the occurrence of *Icerya*, yet but very few of the gentlemen were acquainted with the insect. To show how rare *Icerya* is in South Australia, Mr. J. G. O. Tepper, of the museum at Adelaide, a qualified entomologist, who has collected insects all his life, has known *Icerya* only for the last two years. He never met before this with any specimens in all his collecting trips through South Australia. On October 15 I made a trip with Messrs. Crawford and Tepper to North Adelaide, where some *Icerya* were said to exist; we found there in one garden a few orange and lemon trees with the scales, which were subsequently collected for shipment. In another garden, and also on orange, an oc-

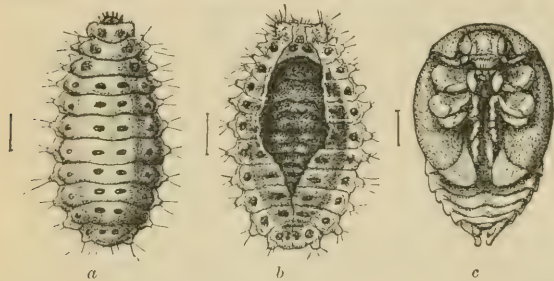


FIG. 2.—*Vedalia cardinalis*: a, full grown larva; b, pupa, dorsal view, inclosed in last larval skin; c, pupa, naked, ventral view—all enlarged (after Riley).



FIG. 3.—*Vedalia cardinalis*, adult—enlarged (after Riley).

casional specimen was found. I discovered there, for the first time, feeding upon a large female *Icerya*, the Lady-bird, which will become famed in the United States—*Vedalia cardinalis* (Figs. 2 and 3). I called

the attention of both the gentlemen to this insect, yet neither of them had ever seen it nor knew the beetle. Mr. Tepper has charge of a large collection of insects, and especially of Coleoptera, at the South Australian Museum. Mr. Smith, the proprietor of the nursery, also called my attention to a beetle, a curculio, which is very destructive to olive-trees, eating the young shoots and leaves of the plants during the night and secreting itself in the ground during the day-time (Fig. 4).*



FIG. 4.—Olive Snout-beetle (*Otiorynchus cribricollis*)—enlarged (original).

Through the bureau of forestry at Adelaide I was informed that a colony of *Icerya* existed at Mannum, on the Murray River, and a trip to that place was made on October 18. In two gardens *Icerya* was present; in one of them they existed on only a few of the many orange-trees, and none examined showed any parasites, while in the other on two

* Dr. Sharp, to whom we submitted specimens, has kindly determined this beetle to be *Otiorynchus cribricollis* Gyll., a common pest to the Olive in the Mediterranean region.

trees that were infested many of the scales were parasitized. In addition to the parasites, numerous larvæ and eggs of a lace-winged fly (*Chrysopa*) were observed, the larvæ preying upon the scales and chiefly upon their eggs. They were covered so much with the cottony matter of *Icerya* as to resemble this insect very closely, and were difficult to pick out from the torn masses of egg-sacs. I also observed here a coleopterous (*Coccinellid*) larva, seen before at Adelaide, feeding on the scales, and this proved to be that of the *Vedalia*. All the scales here, as well as all the predaceous larvæ found feeding upon them, were collected and taken to Adelaide to be shipped to California, together with those found at the latter place. They were kept boxed in a cool cellar. The scales in Adelaide and suburbs were collected on October 24 and 25 at a place in North Adelaide. Nearly every one of the *Iceryas* exposed to light and sun contained parasites, and many of these had already left, as numerous holes were visible. Of the scales found on a small and bushy mandarin tree, where they were excluded from the sun, only a few contained parasites, but the larvæ of the *Chrysopa* were abundant. Most of the larger egg-sacs of *Icerya* were torn by them and the contents devoured.

I observed also that many of the young scales, only sufficiently large to contain a single puparium of the fly, were infested, the expanded skin of *Icerya* forming a thin covering over the puparium of the *Lestophonus*. This was observed at all places where *Icerya* occurred. No doubt the eggs of the pest must be deposited while the scales are yet quite small, probably even before the first molt, and certainly later, as the scales will go on feeding and increasing in size until the larvæ within them pupate. At this time large numbers of the scales were hatching and also of the flies. Only one living fly was observed on October 24 while collecting the scales, sitting between two large egg-masses and hardly visible to the eye. This and a second specimen taken under similar circumstances were the only ones I observed in nature. I have never met with a single specimen depositing eggs or even sitting on an *Icerya* nor flying around. I finished collecting for my first shipment on the 25th and estimated that I had about 6,000 *Icerya*, which in return would produce at an average about four parasites (*Lestophonus*) each. They were packed partly in wooden and partly in tin boxes. Small branches generally full of scales were cut so as to fit exactly lengthwise into the box. With these the boxes were filled and all loose scales placed in between, plenty of space remaining for any of the insects within to move about freely without danger of being crushed by loose sticks. Salicylic acid was used in small quantities in the tin boxes to prevent mold, yet these, as I have been informed by Mr. Coquillett, arrived in a more or less moldy condition, while those in wooden boxes always arrived safe. In addition, Dr. Schomburgh, director of the botanical gardens at Adelaide, kindly fitted up for me a Wardian case which was filled with living plants of oranges and *Pit-*

tosporum in pots. Large numbers of *Icerya* were placed in this, and such larvæ as were found feeding upon them, including some of a *Scymnus** (Fig. 5), only occasionally found with *Icerya*, yet very abundant on various *Eucalyptus* scales, especially on *Eriococcus eucalypti*. Of this I sent large numbers to California in my later shipments, as they were easily collected by the hundreds under bark of *Eucalyptus* infested with this *Eriococcus*. Mr. F. M. Webster brought me the same insect in numbers from Tasmania, together with the *Eriococcus* on *Eucalyptus*. The object of this was to have the *Lestophonus* go on breeding within the case during the voyage. No doubt many infested scales arrived in Los Angeles.



FIG. 5.—*Rhizobius ventralis* Er.—enlarged (original).

I found on examining the tree, on April 12, 1889, under which this case had been placed with a tent over it, that from several of the *Iceryas* the *Lestophonus* had issued. This case, as Mr. Coquillett informed me in letter of November 30, arrived in good condition, except that the putty had been knocked off in several places, leaving holes large enough for the parasites to escape. Before opening the case he found two coccinellid larvæ crawling on the outside, and these when placed with the *Icerya* attacked it at once. He further said that there were only about half a dozen living *Chrysopa* adults. This would show that the *Lestophonus* was still issuing on arrival in California and all turned out more favorably than I had anticipated on seeing the box handled in such a rough manner by the steamer hands at Sydney, to which point I accompanied this as well as all the subsequent shipments. I expected little good would come out of this method of sending and therefore concluded to send only small parcels on ice thereafter, as had been partly done at first. If once the insects could be placed in good condition in the ice-house on the steamer just before leaving, where a temperature of 38° Fah. at first and about 46° Fah. on arrival in San Francisco existed, they must arrive safely. To accomplish this, the parasites with their hosts were all collected the last three days before leaving Adelaide, and on arriving home were immediately placed in a cool cellar. On the trip from Adelaide to Sydney, which takes two days by train, my insects came generally in an ice-box on the sleeping-car.

On November 2 I made a trip to Gordon, 11 miles north of Sydney, Mr. James Harold, agricultural reporter of the *Town and Country Journal*, Sydney, having furnished me with the address of a prominent fruit-grower there. Mr. Harold has traveled much over Australia gathering information for his paper, yet, as he assured me, he never met with an *Icerya*. The same answer was received from the gentleman at Gordon, who has been living in the colony for thirty-four years and has raised oranges for thirty-two years. He knew only the three scales upon

* Dr. Sharp described this as *Scymnus restitutor* (Insect Life, I, 364), but has since written us that it is identical with *Rhizobius ventralis* Er., of the Munich catalogue. He states, however, that it belongs rather to *Scymnus* than to *Rhizobius*.

oranges, viz: *Lecanium oleæ* (Fig. 6) and the *Mytilaspis* and *Aspidiotus aurantii*. This latter is not doing any serious damage to his trees, providing they are well taken care of, yet he assured me that in some parts of the colony it is impossible to raise oranges on account of the ravages of this scale. For the *Mytilaspis* he uses sulphur and lime as a wash, applying it with a paint brush. This he claims need only be repeated every three years, as during this time the trees remain comparatively free. The mixture is prepared in the following way:

Unslacked lime, two parts; sulphur, one part; water is poured on this in sufficient quantities to boil and unite with it. It is applied as a white-wash to the trees and to prevent injury should not be too strong



FIG. 6.—*Lecanium oleæ*: 1, adult females on olive leaves—natural size; 1a, female—enlarged (after Comstock).

Besides the scales, an *Aphis* appears occasionally on orange and peach trees. Two beetles are numerous and destructive to the melon vines here. One of them found at the time is a *Diabrotica*, often received by Mr. Crawford, of Adelaide, as doing great injury to the melon tribe. This gentleman, however, claims that all injury can be avoided by dusting powdered lime over the plants. The beetles, he said, will not attack leaves thus treated. I found here, as well as all over Australia and New Zealand, the Woolly-Aphis (*Schizoneura lanigera*), yet they could be seen only on the branches, as all or nearly all the apples raised in the colonies and New Zealand are said to be grafted on blight-proof

stock. For this purpose, the Northern Spy of our continent is considered the best; next comes the Majetin, as Mr. Will, of Auckland, informed me. The Irish peach was standing completely free of Aphis between badly infested trees. A large number of blight-proof trees are sold by nurserymen in Australia and New Zealand, and only such are planted in these countries as far as the roots are concerned. Mr.

Will said that the Northern Spy will produce the best roots; on this is grafted the Majetin as the stem, and any desired variety may be selected for the upper part or branches. At this place I observed a small black and lemon-yellow lady-bird (Fig. 7) feeding upon the Woolly-Aphis; the same was also observed at Toowoomba, Queensland, under similar circumstances.* I did not meet with it outside of these places. No *Icerya* could be found on the orange trees, but the same day, two young specimens were found in the woods, about 2 miles distant, one of them on a pea-vine and the second on a species of *Salix*, both near the ground.



FIG. 7.—*Leis conformis*, found feeding on Woolly Aphis—enlarged (original).

November 5 I visited Mr. Joseph Purser at Castle Hill, to the west of Sydney, also a prominent fruit-grower. No *Icerya* were found on the numerous orange trees at this place. Mr. Purser reports having met with an occasional specimen only on his orange trees, never more than half a dozen. A short distance from the orchard I noticed a small pond on the edge of which were growing a few small bushes of *Acacia*. On examination I found two large *Iceryas* with egg sacs and several empty skins of scales. Mr. Purser informed me that in former years he has often seen the scales upon trees growing along river banks. During this same day, while searching through the bush, I found upon the needle-bush *Hakia acicularis*, growing amongst numerous *Acacia longifolia*, a well developed *Icerya* fastened to the main stem. A careful search was made on all the plants growing there, yet with the exception of a peculiar *Cœlostoma* upon *Acacia*, no scales could be found. One specimen of *Icerya* was found on this *Acacia* at the botanical gardens in Adelaide. Mr. Purser, who is also much troubled with the *Mytilaspis* mentioned, used as a remedy kerosene-tar, 1 pint; soft-soap, 3 pounds; sulphur, 5 pounds. These are boiled in 10 gallons of water and the trees washed with this mixture with a paint-brush, only the trunk and larger limbs being treated. The gentleman claims that all the scales on trees so treated will be killed and the trees will remain free from scales from seven to nine years.

I returned to Adelaide on November 8, as I considered that the best field to obtain the material. On the 15th a trip was made about 300 miles north of Adelaide, but I found nothing of interest in the insect line on this journey, with the exception along the road of large num-

*This species is *Leis conformis* Boisd., according to Dr. Sharp, to whom we sent specimens.

bers of locusts traveling south in search of food, nothing being left for them in the interior to feed upon. The country around Quorn was so dry and hot that some *Eucalyptus rostrata* in a dry river-bed were all the green vegetation that could be seen, and the locusts still met with were unable to feed. Finding the search for *Icerya* in this district useless, I returned to Adelaide, where subsequently new colonies were discovered for shipment. In conversation about the grasshoppers en route, a gentleman remarked that only in such unusually dry seasons as the present would the locusts migrate, there being no food left for them in the interior of South Australia. Those around Quorn, he remarked, left in a southeasterly direction down the valley toward Adelaide, while those coming from the interior went towards Spencer's Gulf. On my trip I observed them most abundantly about Black Rock traveling south, not in clouds but scattered and never very high, similar to our *Caloptenus devastator* in California in 1885.*

November 29 I began collecting material for my second shipment. Already on some of the trees, well exposed to sun, about 90 per cent. of the flies had left the scales, while on the trees in more shady places more than half of the parasites were still within their hosts. Not a single fly was observed, and yet they must have been about in large numbers. Instead of this, I noticed sitting and walking about the scales a peculiar Chalcid† (Fig. 8); this was suspected to be a secondary



FIG. 8.—*Euryischia lestophoni*, dorsal and side views—enlarged (after Riley.)

parasite, and during the day I noticed them ovipositing in the infested *Iceryas*. The Lady-birds were at that time quite abundant in egg, larva, pupa, and imago states, and special pains were taken not to miss any of these during the collecting. The following four days were

* As kindly determined by M. Henri de Saussure, of Geneva, Switzerland. This is the *Chortologa australis* of his monograph of the Tryxalidæ, not yet completed.

† This is the species referred to in our annual report for 1888, p. 92, under the MS. name *Euryischia lestophoni*.

spent in gathering *Icerya* and its enemies. Many of the secondary parasites were again noticed, yet not a single *Lestophonus*. I gathered during this time probably six thousand scales, and hardly a specimen was noticed among them that was not parasitized by the *Lestophonus*. All of them contained either puparia of the fly or empty holes where the flies had issued. Knowing that if we should introduce the secondary parasite the good work of *Lestophonus* on *Icerya* would be greatly restricted, I sent the following notice to Mr. Coquillett, and also to your office.

On account of a parasite of *Lestophonus icerya*, remove the infested scales that I send from the tree they were placed on, after six weeks, and transfer into large glass jars; examine daily by stupefying the insects that have issued, with chloroform or ether, empty contents on table, pick out the flies and destroy their parasites. Form a new colony with every consignment you receive.

In your letter of January 3 in regard to this secondary parasite you wrote:

The parasite bred from *Kermes* and the one from confined *Icerya* and which you think to be parasitic upon *Lestophonus* are different species of the same genus. The genus is an entirely new one belonging to the Chalcid subfamily *Elasmina*. This subfamily is an extremely interesting one, and up to the present time has contained only the typical genus *Elasmus*, so that this finding of a new genus is important. *Elasmus* contains both secondary and primary parasites, so that it will be necessary to secure pretty good evidence regarding this new form before we can accept it as either one or the other.

From seventy-five specimens of *Kermes* no *Lestophonus* was bred. On the 26th I left Adelaide on my way to Sydney, with what I considered even a better shipment than the first. Unfortunately this lot arrived in a bad condition at San Francisco, owing to a gale on the route when the parcels fell off the shelving in the ice-house, in which they had been placed, and most of them were crushed by cakes of ice falling on them. In my opinion, even such severe treatment as this would not destroy so very many of the pupæ of *Lestophonus*, which are not soft, and if crushed out of the scale will produce flies if properly taken care of later, as I had ample opportunity to observe while in Australia.

Among this lot of things were also about fifteen hundred eggs of the *Chrysopa* which were collected on Kangaroo Acacia (*A. armata*) infested by a *Dactylopius*, which is often taken to be *Icerya*. The scale is sometimes so abundant that the plants are entirely covered with it. This was the case during my visit, and, as Mr. Crawford informed me, also in 1882. Mr. Maskell, to whom specimens were forwarded by Mr. Crawford, said that the insect belongs to the *Dactylopiinae*. The eggs of the *Chrysopa* were so abundant that often from twenty to thirty could be counted on a single small outer branch of a few inches in length, yet many of these had already hatched. The number of Lady-birds in all stages sent with this lot amounted to several hundred. The weather was unusually hot during two days of collecting, the thermometer registered 108° Fah. in the shade, and from one small box left in room over night, where the temperature had not been below 90° Fah., about

fifty of the flies issued during the night and early morning. They were crawling on the window at 6 a. m. Many more were found within the box, with wings not yet developed.

I returned again to Adelaide within four days, the time taken in making the trip. I wrote to the United States consular agent, Mr. George Harris, at Brisbane, Queensland, to ascertain for me the occurrence of *Icerya* in that district. Through the department of forestry at Adelaide I was informed that *Icerya* existed at Stansbury, on the Yorke Peninsula, at the place of Mr. F. Wurm. Accordingly a trip was made across the water on October 1, and I was kindly and hospitably received by Mr. Wurm. That gentleman showed me a small orange-tree completely covered with *Icerya*, but aside from this, not a single specimen could be found for miles around, nor had they ever been observed before this. The tree infested with the scales was completely covered with a small black ant, so much so that several could be counted upon each of the scales at the same time. Upon examination only two specimens of the *Icerya* were found to be parasitized by the *Lestophonus*, and these had already left. No doubt the abundance of the ants upon the scales prevented the flies from ovipositing. I recommended keeping the ants off the tree as the scales would then disappear.

How often must the mother flies have been hovering over this young tree in their attempt to lay eggs, and how many of them must have been carried off as food for the young of the industrious ants! Mr. Wurm also informed me that *Icerya* had been found by him upon the roots of black grass. On examination, however, this proved to be an entirely different coccid, *Lecanium oleæ*, which had found its way to this place in small colonies on olive-trees. The cut-worms had done considerable damage to fruit-trees, grape-vines, and other vegetation during November. Some of the apple-trees were completely stripped of their foliage. Melolonthid larvæ had been very injurious to the wheat crop by eating the roots.* The common grasshopper was also in abundance here.†

On December 6, from four large specimens of *Icerya* that had been inclosed, thirty-four flies (*Lestophonus*) and five parasites of the latter had issued. I examined condition of *Icerya* on place from which last sending was made, and from which nearly every one of the old and infested scales had been removed, the trees at the time being full of large *Iceryas*; yet at this date but very few of them were left, the coccinellid larvæ and the *Chrysopa* in conjunction doing good work, eating, no doubt, the healthy as well as the infested scales. Some of them had apparently gone through second molt, yet the greater part were

* Three species of Melolonthid beetles were collected at this point by Mr. Koebele, and being unknown to our fauna were sent to Dr. Sharp, who has found them to be *Scitula nigrolineata* Boisd., *S. pruinosa* Dalm., the third species representing a new genus near *Scitula*.

† The same undetermined species referred to on p. 17.

still in the first stage. Only very small larvæ of the *Lestophonus* were found within scales after first and second molts. Within a nearly full-grown specimen on trunk of lemon-tree, the only large one found there, two larvæ of the fly were nearly full-grown.

I left on December 10 for Melbourne, seeing that it was necessary to hunt up a new field. There I had hopes of gathering a sufficient quantity for a shipment. The largest colony I was able to discover at Melbourne existed in a church-yard on Collins street, upon small trees of *Pittosporum undulatum*. I could not find the proper person to apply to for admittance, and a policeman whom I consulted in regard to getting the tempting specimens advised me "not to jump from the fence as they surely would have me arrested."

I left them undisturbed and went in search of others. A few specimens existed in the gardens of the government buildings; an occasional specimen in the park adjoining the Exposition grounds; some on a hedge in front of a hotel, and single specimens were found on trees in a park at St. Kilda, while at the same place on a garden hedge quite a number were found; all these on *Pittosporum undulatum* and *P. (engenioides?)*. At the last-named place the lady-birds were found at work, and all were gathered later for shipment. I went east of Melbourne as far as Bairnsdale, yet no *Icerya* could be found. A strong attempt was made to find out the whereabouts of the Monophlebid of which Mr. Crawford had sent specimens to California. They could not be discovered in numbers in the woods, yet in the parks at St. Kilda I was soon rewarded, by finding the insects looked for, viz.: *Monophlebus crawfordi* Maskell (Fig. 9), under loose bark of various Eucalypti, embedded in cottony matter, and the single, (often 2 inches) long, white, setous, anal hairs sticking out.* Only a few dozen of the monstrous scales, however, could be gathered in a hard day's work. Up in the tree-tops I often found a similar Monophlebid, only varying in color somewhat. It is as large, or even larger, than *M. crawfordi*, and sits fastened to the branches and exposed without any cottony attachments, although sometimes under chips of bark.

On my way home in the evening one of these scales came hurriedly running down on the trunk of a tree. So the next day, at the northern park at Melbourne, the ground at the base of the Eucalypti was examined. Here I found, sometimes lying loose on top and dead (in this case always destroyed by *Lestophonus*) and below ground to a depth of 3 inches, in a small cave nicely embedded in loose cottony matter if healthy, or generally mixed up with the ground if parasitized, large numbers of these scales. These, Mr. Coquillett informed me on my return to Los Angeles in April, gave the best results in *Lestophonus*, as these parasites were still issuing then, four months after they were col-

*Not mentioned in the description of *Monophlebus crawfordi*. See "On some New South Australian Coccidæ," by W. M. Maskell. (From the Transactions of the Royal Society of South Australia 1888.)—A. K.

lected. I have counted as many as sixty-two holes in one of these scales, showing what a number of parasites they are able to support. A third species of these large Coccids was found attached to the roots and base of Eucalyptus below ground, even larger than the two preceding. About forty specimens of these produced no parasites. One specimen, probably of this latter species, was found embedded under bark between the forks of a very large Eucalyptus about 8 feet from the ground. This measured fully 1 inch in length, and was about two-thirds as broad, being nearly round.

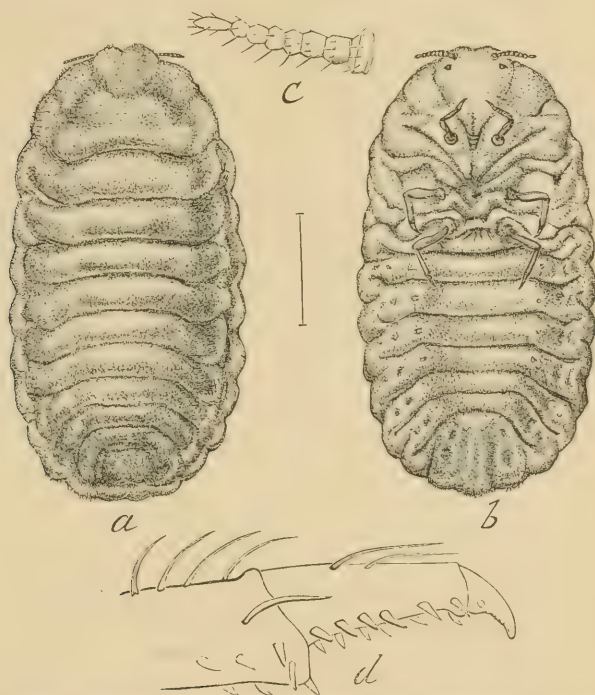


FIG. 9.—*Monophloeus crawfordi*: a, female from above; b, same from below—enlarged; c, antenna; d, tarsus of same—still more enlarged (original).

I left for Sydney on the 24th to place the insects in an ice-house previous to shipment. In the meantime a letter had been received from Brisbane stating that *Icerya* occurred there occasionally in numbers, and having had a letter from you in which you expressed the hope that I would be able to visit Mr. Carl H. Hartmann, a correspondent of yours at Toowoomba, who had found *Icerya* on his oranges in 1886, I started for Queensland on December 29 and arrived at Toowoomba early on January 1, 1889. During the same day a full-grown female *Icerya* was discovered in the woods about three miles from this place on *Acacia decurrens*. During a search of several hours no other specimens were found. I visited the Range nursery the following day and met the son and the brother of Mr. Hartmann, who himself had died from the effects

of fever contracted while on a scientific trip to New Guinea. I also met the man who had been employed at the time in 1886 when Mr. Hartmann received an illustration from Brisbane of *Iceerya*, and directed him to look over the trees for specimens, when several scales were found. Since then, however, none have been found. While looking over the lemon and orange trees I found one single nearly full-grown specimen, but aside from this no trace of them. A peculiar Coccid resembling *Iceerya* somewhat in structure was found on an apple-tree. The gentleman informed me that *Iceerya* was always most noticeable in wet seasons, but that it never appeared in such numbers as to be injurious.

I found here in abundance the large hemipterous insect so destructive to the orange in Queensland and New South Wales. A second species somewhat smaller than this, yet equally mischievous, was found at Adelaide (Fig. 10). Trees were observed at this place with all the



FIG. 10.—*Mictis profana*—natural size (original).

fruit and most of the young shoots destroyed. Both species live and grow upon the sap of fruit and tender twigs.* *Aspidiotus aurantii* was present here in numbers and also *Lecanium olea*, both upon oranges; the latter, however, is kept well in check by a lepidopterous (Noctuid) larva, *Thalpochares cocciphaga*, Meyrick (Fig. 11).



FIG. 11.—*Thalpochares cocciphaga*—slightly enlarged (original).

Several young orange trees had been completely cleaned by larvæ, and eight chrysalids were found upon a young plant. Mr. H. Hartmann also informed me that near Brisbane a dipterous larva existed which occasionally destroyed all the orange crops, and in 1886, which was a very wet season, a dipterous larva destroyed not only all the oranges but also nearly all the other fruits, even the apples and pears. He also gave me the following list as blight-proof apple-trees: "Northern Spy, Majetin, Irish Peach, Streaked Peach, Hartmann's Seedlings Nos. 1 and 5, New England Pigeon, Shepherd's Perfection, Chubb's Seedling, Canvade, Flushed Peach."

On January 5, having obtained free passes for the Queensland railways, I left Toowoomba for Brisbane. On my arrival at the hotel I met with specimens of *Iceerya* on an ornamental plant in the passage-way. This and a few other specimens found in gardens through the city were all I could find, yet in damp seasons they occur sometimes in numbers, as I learned from several gentlemen acquainted with the insect.

Mr. Henry Tryon, assistant curator of the Museum, kindly introduced me to several persons in Brisbane. He himself was about to publish a

* The second of these insects is *Mictis profana* Fabr., and the other is a species of *Aspongopus*.

paper on *Icerya* and its parasites, of which he has shown me a small Chalcid of which he bred several specimens from *Icerya* inclosed in paper box, saying it was a true parasite.* I bred this same insect from a few specimens of an *Icerya* sent to me by Dr. Bancroft, of Brisbane, as feeding upon mangrove tree (*Avicennia officinalis*, Linn.). This scale differs in coloration from the true *I. purchasi* and may prove to be a new species. Mr. Maskell, to whom the insect was shown, thinks it only a variety. It would be an interesting one, however, for of all the *I. purchasi* that I have seen, none show such a uniform bright yellow color. No specimens found on mangrove at Auckland show such bright yellow color. Mr. Tryon is of the opinion that *Icerya* originated in China, from the fact that nearly all specimens he found at Brisbane were upon plants from that country. Dr. Bancroft, in his paper on Coccidæ (Philosophical Society of Queensland, vol. 1, August, 1869), referred to the then undescribed *Icerya*, and at that time, as he assured me, he had been acquainted with the insect for several years. The doctor further mentioned the occurrence of a scale on the sugar-cane in Queensland living on the roots of the young plants, and as these became larger, behind the leaves. It had been imported with the canes from Mauritius. He promised to secure specimens for me. No doubt this will prove to be *I. sacchari*.†

In the woods around Brisbane but few Coccids were found during my brief stay. The white waxy scale (*Ceroplastes*) so abundant on various plants in cultivation was here observed in large numbers upon a small shrub. Of the *Monophlæbus*, which I had been informed was almost always numerous around Brisbane, only an occasional specimen could be found. Everything was so extremely dry that I gave up my intended trip by steamer further north, and as there was little prospect of obtaining sufficient material for a shipment at this place, I returned slowly towards Melbourne, making occasional stops along the road, yet without discovering any *Icerya*. At Melbourne I was fortunate in finding many more of the *Monophlæbus*. On a few trees, under the bark, they occurred by the dozens, often many together, but they were all dried up and the flies had left sometime previous. Those in ground were still in good condition. A large number of them had deposited their eggs and were shriveled up, yet during the two days a fair number were found parasitized. At Sydney, January 21 to 23, a number of *Iceryas* with parasites, and probably two hundred or more of the Lady-birds in all

* Mr. Tryon has recently published in a pamphlet entitled "Report on Insect and Fungus Pests, No. 1," a general description of this parasite, but without attempt to name or properly place it. From the description it seems to be identical with a true parasite of *Icerya*, which we have received from Mr. Crawford, and which we have characterized, since the above was in type, as *Ophelosia crawfordi*, n. g., n. sp.

† We find among Mr. Koebele's Brisbane material a small Coccinellid not here referred to, but which is labeled "feeding on *Icerya*." Dr. Sharp, to whom we sent a specimen, determines it as *Cryptolemus montrouzieri* Muls.

stages, were collected, most of them in the Town Hall garden. I found here also feeding upon the Scales a few specimens of a small *Seymnus* in all its stages which were inclosed.* The first brood of *Icerya* in warm and exposed places at Sydney had by this time become nearly grown, some of them beginning to exude cottony matter, while others in more secluded spots were quite small. The isolated acacia tree, so full of *Icerya* in September, had become entirely clear, nothing but a few old and torn egg-masses being visible. With this I finished collecting the parasites and enemies of *Icerya* in Australia, as from letters received from Mr. Crawford, at Adelaide, dated January 11 and 12, there was little hope of obtaining sufficient material at that place for another consignment, nor would it have paid to search for *Monophlæbus* in the ground, as at the time they could not be found in large numbers in the woods. Moreover, many of their parasites had already left, while the *Icerya* still known to me at Melbourne and Sydney were not sufficient to make a good shipment.

A letter received at this time from you in which you directed me to visit New Zealand and study *Icerya* there until the arrival of the next steamer for San Francisco, in case the exposition commission would pay expenses, was shown to Hon. Frank McCoppin, who at once consented to my proposed trip. I therefore left Sydney on the steamer of January 23 with some hope of clearing up the mysterious disappearance of *Icerya* in New Zealand. Arrived at Auckland on the 28th, the Scales with parasites and Lady-birds were repacked from tin into wooden boxes, and were found in excellent condition. Everything within the tin boxes had the appearance of being placed there only a few hours previous. There was no indication of any mold. Some fresh *Iceryas* found in a private garden at Auckland, on *Acacia decurrens*, were inclosed as food for the Lady-bird larvæ. These latter Scales were in a small colony all close together on a few small branches, and numbered about eight hundred specimens. No insects preying upon them were found. At the United States consulate a letter was found awaiting me from Mr. R. Allan Wight, dated October 10, 1888, in which the writer mentioned various localities infested with *Icerya*, wishing me to visit Hawke's Bay, at Napier, where the Scales were still numerous, although fast disappearing, and where a good field for observation would be open. I therefore left Auckland on January 30, overland, the New Zealand Government, through our consul, having furnished me with a free pass for four months. On this trip not many observations could be made.

The Cabbage Aphis was found in large numbers all over the northern island of New Zealand as well as in Australia. A Coccinellid was found subsequently at Napier feeding upon this Aphis in large numbers. It is described by Mr. W. Colenso as *C. nova zealandica* (Fig. 12). About fifty specimens of these were collected and placed in empty pill-boxes. Of these twenty-one were still living on my arrival at Alameda, where they were liberated. A second species was found feeding upon the Aphis in

* Specimens of this insect were also sent to Dr. Sharp, and determined as belonging to a new species of a new genus.

small numbers; this is *C. tasmanii* (Fig. 13). The Cabbage Plutella (*Plutella cruciferarum* Zell.) was here as well as all over Australia, observed to be very abundant. Mr. French, of Melbourne, had a specimen on exhibition with the name of "*Plusia crucifera*" as injurious to cabbage. The small Tineid, so destructive to potatoes in California, and no doubt already distributed over the most of the Western States, has been known in New Zealand for years, and it is doing the same mischief all over Australia, where it originated. In conversation with a merchant from Denver, Colo., recently, he said that a year ago he received three car-loads of California potatoes, infested with these worms to such a degree that they could not be sold. I also met here, wherever apples are grown, with what is probably *Mytilaspis pomorum* Bouché, the species previously referred to as such.

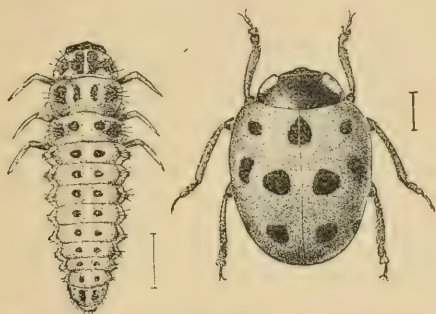


FIG. 12.—*Coccinella nova-zealandica*, larva and adult—enlarged (original).



FIG. 13.—*Coccinella tasmanii*, adult—enlarged (original).

Mr. A. Hamilton, curator of the museum at Napier, who had been informed by Mr. Wight of my intended trip, awaited me and at once showed me a number of infested Acacia trees. *Icerya* was here still in countless numbers. Before breakfast the next morning this gentleman showed me one of the Australian Lady-birds,* saying that he found it among *Icerya*. On investigation they were found in large numbers in every place visited at Napier and several miles out in the country. I left Napier for Wellington on the 11th to visit Mr. Maskell. This gentleman had never had the opportunity of studying the enemies of *Icerya*, as the scales are not found anywhere within 80 miles of Wellington. It had been the firm belief of some persons in New Zealand that certain Ichneumonids were the destroyers of the Scales. I saw dozens of several species of these upon one orange tree infested with *Icerya* near Napier, not injuring them in any way, but devouring the sweet exudation from them. Larger numbers of flies were present than Ichneumonidæ, and even Crambidæ were engaged in the same performance, yet these received no share in the compliments. Mr. Maskell had received from the Cape of Good Hope about two hundred specimens of several species of Coccinellids, which, as the sender informed him,

* *Vedalia cardinalis* Muls.

were all preying upon *Icerya*. They were sent to Nelson and placed under tent with the Scales. A few days later, however, the wind took away the tent and nothing more has been seen since of the Coccinellids. Several species of these beetles which Mr. Maskell kindly presented me with were left with you at Washington. Amongst them I could not find the *Rodolia iceryæ*, Janson (Fig. 14), which is destroying the Scales at the Cape and, with the possible exception of one species, I do not think they will feed upon *Icerya*.



Fig. 14.—*Rodolia iceryæ*—enlarged (after Riley).

My time was too short to visit Nelson, and Mr. Maskell kindly promised to secure for me a box full of scales from that district, so as to enable me to find out whether some parasites or enemies existed there. This box was sent to me on board the steamer at Auckland and, on opening the same, several flies were found that had issued en route. Only one of them was in perfect condition; all the others were crippled. They had crawled in among the paper used in making up the parcel. No other specimens were bred and no holes were observed in the scales, so the only possibility remains in the larva of this fly being predaceous upon the eggs of *Icerya*. Apart from these flies no other insects were observed from the Nelson Scales. On my return to Napier I got at once to work gathering the Coccinellids in all stages. They were in such numbers that I found it not very difficult to collect here about six thousand specimens during the three days (February 14 to 16). As many as eight eggs of the Lady-bird were observed on the upper side of the female *Icerya* just beginning to exude cottony matter. Opposite to this on the small branch of *Acacia*, five young larvæ of the Lady-bird were feeding on the under side of a half-grown scale; in one instance even nine Coccinellid larvæ were found attached to a small



Fig. 15.—*Scymnus fagus*—enlarged (original).

Icerya. The mature beetles were not numerous, but every branch full of scales had a greater or less number of eggs and larvæ. The eggs are chiefly deposited among the vigorous half-grown scales. Here the largest number of the eggs and young larvæ were found. They are generally single, thrust in between the scales and fastened onto the branch, on the scale itself, and often on the under side of the scale, as the mother Lady-bird will sometimes raise the *Icerya* with her hind legs and thrust the egg under it. At times two or more are found together, always lying flat and in irregular position. Aside from this valuable Coccinellid, a small *Scymnus* was observed here feeding upon the scales, but in small numbers only. This was named for me later by Captain Broun, as *Scymnus fagus* (Fig. 15).

I left Napier with my valuable lot of Lady-birds on the 17th. They

were placed in the ice-house on the steamer, and as soon as Auckland was reached I went to the freezing-house and there my Coccinellids were placed in a cool room with a temperature of 38° Fah. Having been informed that *Iceryas* had been very numerous almost a year ago at a gentleman's place near Lake Togabuna, several miles out of Auckland, a trip was made as soon as my Lady-birds were safe, for I was very anxious to get at the fact as to what had destroyed the Scales around Auckland, and if it were not the same insect found at Napier. I was shown a couple of *Acacia* trees, one of which had been destroyed by the Scales, and a second, still living, which had many *Iceryas* upon it. All the Scales on this small tree were examined, and, with the exception of a small Coleopterous larva within one of the egg-masses, no enemies could be observed. Both these trees were growing among old pine trees and were much shaded by them, in fact so much so that no sun-loving insect like the Lady-bird would venture into them. Close by about a dozen orange trees were growing in an open field, and on my inquiring if no Scales were upon these trees, the gentleman remarked that only about nine months since they were full of them, but that all had disappeared. These I wanted to see, and on the first tree reached, while yet at some distance, I could see, exposed to the sun on the upper side of a leaf, a black glistening spot, which was the insect looked for, the Australian Lady-bird. On this tree more Coccinellids than *Iceryas* were found. The Lady-birds, if not at rest on top of a leaf in the hot sun, were busily running or flying about. This is an interesting fact. All the orange trees in the open field were completely cleaned of the thousands of Scales by the Coccinellids, while closely adjoining, among the dark and shady pines (*Pinus insignis* Douglas), a large *Acacia* tree (*Acacia decurrens*) was destroyed by the Scales, even the adjoining branches of the pine trees being dead, and, as stated by the proprietor, from the effects of *Icerya*.

As yet the scales have not been observed to my knowledge on pine trees in California, yet Mr. Maskell also told me of having seen pine trees loaded with them. I observed here also an *Aspidiotus* very injurious to apple trees. The following day the place visited on my first arrival in Auckland was examined again, but only a few large females could be found. The young were just hatching, and many eggs were still present. Mr. Cheeseman had been informed by Mr. Purchas and others that *Icerya* existed abundantly in the woods at the English church cemetery (Paeroa), infesting *Sophora tetraptera*. He kindly accompanied me to the place, and before long pointed out the tree, which is closely related to the *Acacias*. We soon succeeded in finding the scales in large numbers on a few of the trees, when a careful investigation was made and a few specimens of the small *Seymus fagus* were found. A small hemipterous insect was present among the egg-masses in all stages, the young being found within them, and two species of small spiders had built their houses among the egg-masses

also. From the many remains of the young *Iceryas* it was evident that they fed also on these. The Australian Coccinellid had not yet discovered this colony of scales, yet it must have existed here in numbers for at least four years. Only a few scattered specimens were found on other shrubs, but they had spread to the Mangrove bushes growing close by in large numbers. On this plant they thrive remarkably well.

Captain Broun, at Drury, the authority on New Zealand Coleoptera, was visited and asked in regard to the Australian Lady-bird. He did not know the insect, nor had he ever met with it, but he had the small *Scymnus fagus*, which seems to be more widely spread and lives upon various Scales; neither had he met with the common *C. nova-zealandica* which I found at Napier. During a ramble in the woods with the captain I found a large Coccinellid in all stages feeding upon *Ctenochiton viridis* Maskell infesting *Coprosma lucida*. This Coccinellid was identified by him as *Leis antipodum* Mulsant (Fig. 16). Upon the same tree was also found in abundance a second and smaller Scale of the same genus; this is *C. perforatus*. The captain kindly promised to send me a number of living specimens of the Coccinellid, and he kept his promise, though, unfortunately, the insect had become so rare that with assistance he was able to find only six specimens. These came in an ice-chamber well packed in a large box, but only one of them was living on arrival here.

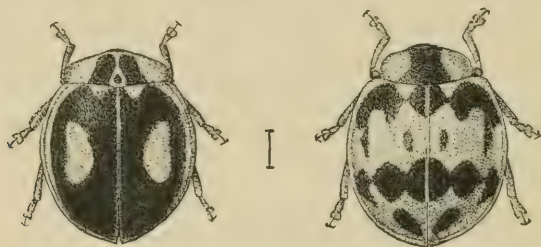


FIG. 16.—*Leis antipodum*, two varieties—enlarged (original.)

On February 25 the steamer was ready to sail. Having made arrangements with the butcher on board the previous day as to the most convenient time of receiving my insects into the ice-house, they were transferred from the freezing-house on board the steamer, which did not take more than ten minutes, and the insects were not disturbed in their dormant stage during the time. Every day on the voyage I received the answer from the butcher, to my inquiries about the parcel, "Your bugs are all right." On March 10, after leaving Honolulu, one of the boxes with the Lady-bird larvæ was examined and found in excellent condition; no dead larvæ could be found among them, and this was twenty-four days after the first were collected. On Saturday evening, March 16, we arrived at San Francisco, too late to have the insects forwarded, and I could not send them off before Monday evening, March 18. They were probably received and opened by Mr. Coquillett two days later. This would make thirty-four days that they were in-

closed, and yet they arrived in excellent condition, better than any previously received. Having been on ice for twenty-nine days, no doubt many of the eggs arrived here before hatching, and the larvæ under such conditions would make little progress in their growth.

As will be seen from these notes (and such is my firm belief), *Icerya* is indigenous to Australia, having spread from that country to the Cape of Good Hope, New Zealand, and our continent, and no doubt with some plants brought here. The pursers on steamers running between San Francisco and Sydney informed me that with every trip a greater or less number of plants are brought over. On these no one would notice *Icerya*; even an expert would overlook a few of the tiny young scales if not especially searching for them. At the time *Icerya* was first observed here many oranges were brought over. Mr. Sutton, of the Alameda, informed me that in 1873 the entire market in San Francisco was supplied with Australian oranges. All this matters little. We have the pest, and now the most effective enemies of it. Before long the work of the latter will be appreciated all over the State. At this date small colonies of the Lady-birds have been established in almost every district infested with *Icerya*, and at Los Angeles they must be present already by the thousands.

It was difficult in Australia to ascertain which was the most effective enemy of *Icerya*, on account of the scarcity of the latter insect during the unusually dry season of my visit. It is safe to say, however, that the Lestophonids are always and at any time ready for any *Icerya*, since they breed upon so many and varied Scales infesting the Eucalypti and Acacias, of which the Australian woods chiefly consist. Often *Icerya* will appear in large numbers in some private garden in a city, and yet, as I have been informed, they will be out of sight in a short time again. This entire clearing up is the work of the Lady-birds, for in most cases the infested scales will produce eggs, and the flies are never able to entirely clear a tree of them, in which case the Lady-bird steps in and devours Scales, flies, and all. It is only in such protected places that the scales sometimes become numerous, as it takes time for their enemies to establish themselves. The *Lestophonus* no doubt would in time increase here so as to keep the *Icerya* in check, but this would be years, for only two broods of it were observed in Australia, as many as that of its host, the *Icerya*, the parasite appearing about the same time as the young of the latter. I have seen about eight species of Monophlebidae upon which *Lestophonus* will undoubtedly breed.

Dr. Diez, of the Adelaide Museum, has shown me several specimens of a species of these scales, which he assures me were fully 2 inches in length when received alive from the interior of South Australia. He had written to the party who sent them for information regarding the monstrous scale-bug, yet the only light he received upon the subject was that the discoverer of the Scale was found dead in the bush near

Baroota, and he assumes that they came from that district. Such a large Coccid would be able to support several hundred of the *Lestophonus*. I have also bred this fly from a species of *Caelostoma* found on a shrub at Mount Lofty, South Australia, where two specimens of *Icerya* were found, both invested by *Lestophonus* on a species of *Acacia*. In California we have to my knowledge no Scales upon which this fly would breed, with the exception of *Pulvinaria* and *Dactylopius*. Of the latter there are many species found almost everywhere; a large species almost equal in size to *Icerya* exists upon our Redwood trees (*Sequoia*). This no doubt will in time be attacked by the flies. I have not the least doubt that in time this *Lestophonus* will do effective work upon *Icerya* even if slow (too slow for the Americans, as Mr. Wolfskill remarked). So far I have seen little progress of it. On my visit to Los Angeles (April 12), it seemed that very few remained of the vast number of flies received here in good condition. All had been placed under one tent, erected over a tree for the purpose of propagating, instead of forming a new colony with every consignment received; yet it is to be hoped that very many of the flies have escaped from the tent.

As far as the Lady-bird is concerned it will show itself, or rather has done so already. They never were found by the writer except feeding upon *Icerya*, and yet there must surely exist in Australia some other scales upon which they feed. The work this little insect is able to accomplish is shown by the fact that by chance it went over to Auckland, New Zealand, where the *Icerya* was in a flourishing state, having destroyed nearly everything about five years or so since, and there cleared nearly the whole district around Auckland within about two years. From here it has spread south as far as Hawk's Bay without any artificial help, everywhere increasing in numbers as long as the food would last. I shall be greatly mistaken if this one insect alone is not master of the situation within two years' time, although we have comparatively few to battle with. It will need thousands everywhere to clean up the millions of scales. I have no time while in the field to study much of the life-history of this valuable insect. My first motto was always "get as many as possible." If once established here, the life history may be studied at leisure.

I will, however, relate part of the doings of one pair of these insects. On February 9 a few beetles and pupæ were collected in a glass jar. Two male Lady-birds were noticed running and pushing around one of the pupæ in which one of the female Lady-birds had just issued and was within the case with soft and tender wings and about helpless. Soon the male succeeded in pushing her out, and immediately after this had been accomplished, one of them united with her at about 3 p. m. This pair were placed in a small wooden box and they remained in copula until the following morning at 7. They were left in this box until February 17, when they were placed in a large jar with twigs of *Acacia* full of *Iceryas*. No eggs were observed in the box, which was completely

clean, with the exception of the numerous red spots produced by the Lady-bird, for they had subsisted on their own eggs during their confinement. As soon as the female Lady-bird was among the scales she became quiet, stopped, and deposited an egg upon the twig. As soon as this was done she turned around and devoured the same, which took her about a half a minute. A few moments were spent in cleaning herself and then another egg was brought forth and eaten. After this and another wash she attacked and devoured a half-grown scale. This was eaten into from the back, very quietly at first, yet in a little time she became lively, almost furious, tearing the scale off from its hold by the beak and turning it up and down in the air with the mouth-parts, assisting in this with the anterior legs. In about one minute this was devoured and nothing but the empty skin left, after which she went to work, business-like, and deposited eggs quietly, sitting at rest upon the scales, and every few minutes thrusting an egg in between or generally under them. A very large scale was lifted with the posterior legs and the egg thrust beneath. All the strong attempts at love affairs by the lively and not hungry male were resisted. I was careful to see that twigs with nothing but *Icerya* on them were selected for food; at least no young larvæ could be observed on them; yet the second day after the *Coccinellids* were placed in with them, young larvæ were seen, and they came out so fast that within a few days my jar was a living mass of them.

On February 22 a few of the larvæ were full grown and settled down in a quiet place, fastening the ends of their bodies down with a thick and sticky substance and remaining in this way, becoming shorter and stouter, for four days. On the 25th the first pupa was observed; from this the mature beetle hatched in the evening of the 28th. Another appeared the following day. Again, on March 3, a pair of the bred Lady-birds were placed together, with clean food, and the next day, March 4, eggs were observed which hatched on the 8th. This I could not carry through, as the food began to dry up; in fact, on March 18, many grown and hungry larvæ were devouring each other in this jar, and even the mother of them, which was still living, was noticed devouring one of her young, a larva. Three times, at intervals, this pair were observed in copulation. Eleven beetles of this last brood reached maturity, having had nothing to feed upon but one supply of scales that had already been boxed up for eight days, the beetles having been born and forced to live upon one another. Taking four days for the eggs to hatch, about eight days for the larvæ to grow, three days until pupating, and four days more for the pupa to emerge, this would only make nineteen days from the egg to the mature insect, providing the weather is warm. No doubt we will see cases where, in less time than this, all the stages are gone through at Los Angeles in hot weather, and we may expect at least fifteen broods annually of this insect to two of *Icerya*.

Another most important insect is the moth *Thalpochares cocciphaga* Meyrick. It is greatly to be hoped that this insect will be introduced here. I have been able to get about a hundred larvæ here in good condition, yet what became of them I am not able to state as yet. The insect is apparently easy to breed. Five of the larvæ were placed in a pill-box in the field during January and overlooked. During April, on opening the box at Alameda, I found that four of the moths had issued, copulated, and deposited many eggs. The young larvæ, however, had already left the box and no trace of them could be found. It would have been easy with the number received here, had a little care been bestowed upon them, to breed and introduce them upon most any of our larger Scales.

The *Chrysopa*, of which eggs and larvæ were sent over with every shipment, excepting the last, have been successfully introduced. In April, while in Los Angeles, several of the insects were noticed upon orange trees in Mr. Wolfskill's orchard.

Several species of *Scymnus*, about six in number, that were sent, all live upon *Coccidæ*. The largest of them was abundant in Brisbane upon various soft scales, and was also found at this place upon *Icerya*.

Mr. Webster brought to me from Tasmania a box full of *Eucalyptus* twigs with *Eriococcus eucalypti*, the *Scymnus* so numerous at Melbourne, and sent here in numbers, together with two small moths, a Pyralid and a Tineid, which were feeding upon the *Eriococcus*.* These, as all other insects, were turned over to Mr. Coquillett. Various other beneficial insects were observed during my four months' work in Australia, all of which if introduced here would be of great value. One of these deserves to be mentioned. It is one of the largest Lady-birds, and had cleaned whole apple orchards of the Woolly Aphis in South Australia and Victoria. They were also observed to feed upon *Lecanium*.

All material collected and studied in Australia relating to this subject and otherwise of importance will be mounted and sent to you with the notes thereon.

* These moths we have no means of now determining, even if described. The Tineid much resembles *Euclemensia bassettella* of this country, and the other is a Phycid near *Dakruma*.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 22.

R E P O R T S

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

(PUBLISHED BY THE AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1890.

Supplements of

J M Rusk

Secretary of Agriculture

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DIVISION OF ENTOMOLOGY.,
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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January —, 1890.

SIR: I have the honor to submit for publication Bulletin No. 22 of this Division. Owing to the necessities of the case I was able to include in the annual report only a general summary of the work of the field agents of the Division, reserving their full reports on the work of the year for subsequent publication. They are, therefore, here presented.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

This bulletin comprises the reports of the field agents of the Division of Entomology which were necessarily omitted from the annual report, in which it has been our previous custom to publish some or all of them.

Mr. Coquillett has reported upon several phases of his work, and we print here only the portion relating to the experiments which he made in the destruction of the Red Scale of California (*Aspidiotus* [*Ionidia*] *aurantii* Maskell) by the use of washes. A portion of his report relating to experiments with gas treatment for this scale insect, resulting in the great cheapening of the use of this process, has been printed in the double number of INSECT LIFE for January and February, 1890. Another section of his report relating to the attempted colonization of the insects preying upon *Icerya purchasi*, imported by Mr. Koebele from Australia, has also been published in part in INSECT LIFE for October, 1889, and the remainder is reserved for future use. The experiments with washes were undertaken with a view of presenting a practical illustration of their utility to the fruit-growers of southern California who had apparently ignored the previous results obtained and published in our reports for 1886 and 1887. These late experiments were performed by instruction of Assistant Secretary Willits, and the Red Scale was particularly chosen on account of its importance as a pest, and for the further reason that the Fluted Scale seems at present to require no further experimentation, since the Vedalia is overcoming it so rapidly.

Professor Osborn, in obedience to instructions, has taken up the study of insects injurious to grasses in addition to his regular work upon the insect parasites of domestic animals, and reports at this time upon the leaf-hoppers injuring forage plants. This is a comparatively new and important field of investigation.

Professor Webster continues his studies of grain insects and reports here upon certain points connected with the economy of a few well-known pests.

Miss Murtfeldt sends in a general report upon the insects of the season in eastern Missouri, brings out a number of interesting facts, and gives the life history of a beetle injuring Spinach and also the histories of two interesting Saw-flies.

Mr. Koebele returned from Australia in March and came on to Washington for special work, returning to Alameda, Cal., April 15. He spent considerable time in writing out his report on his Australian work (published in Bulletin No. 21 of this Division) and in assisting to rear and distribute the *Vedalia*.

During the latter part of the season he did considerable field work and reports upon a number of injurious species. Perhaps the most interesting feature in his report is his work upon the enemies of the Codling Moth in California. He has reared four entirely new parasites of this species, two of which are primary and two secondary. The egg parasite seems to be a very important feature in the life of the Codling Moth on the Pacific coast, and we know from previous experience with egg-parasites of the same genus that they are capable of very rapid development and are consequently very beneficial insects where they attack injurious species. We need only refer to the case mentioned in the Fourth Report of the U. S. Entomological Commission, where by the work of *Trichogramma pretiosa* Riley, the fifth brood of Cotton Worm was almost completely annihilated in Florida, where at the beginning of the fourth brood less than one-half of the eggs had been destroyed. By almost complete annihilation we mean that less than 10 per cent. of the Cotton Worm eggs throughout a large section remained unstung.

Professor Bruner treats of the insects of the year and enters upon the consideration of insects detrimental to the growth of young trees on tree claims in Nebraska and other portions of the West, an important subject which has not before received treatment.

C. V. R.

REPORT ON VARIOUS METHODS FOR DESTROYING THE RED SCALE OF CALIFORNIA.

By D. W. COQUILLETT, *Special Agent.*

LETTER OF TRANSMITTAL.

LOS ANGELES, CAL., October 30, 1889.

SIR: I herewith submit my annual report on some of the results obtained by me during the past year.

During the first half of the year nearly my whole time was occupied in propagating and distributing the Lady-birds (*Vedalia cardinalis* Mulsant) recently imported from Australia by this Division. So thoroughly have these insects destroyed the Fluted or Cottony-cushion Scale (*Icerya purchasi* Maskell) that at the present time it is difficult to find a living specimen in any portion of the southern part of this State. From the 129 Lady-birds received from the 30th of November to the 24th of January and colonized under a tent covering an orange tree in this city, by the following mid-summer I had, with the help of Mr. J. W. Wolfskill and Mr. Alexander Craw, distributed nearly 15,000 of these insects to various parts of the State, which will give some idea of the great fecundity of these insects. My first attempt at colonizing them on trees in the open air was made in the 35-acre orange grove belonging to Col. J. R. Dobbins, and located in the San Gabriel Valley in this county. I colonized 35 of the Lady-birds on one of the trees February 22 and about 100 more on the 20th of March, and Colonel Dobbins writes me that they had practically freed his grove of the Iceryas by the 31st of July.

The large Chapman orange-grove, also located in the San Gabriel Valley, and comprising 150 acres of citrus trees, has likewise been practically cleared of the Iceryas by these Lady-birds, the first colony of which I placed in this grove on the 20th of March. As might naturally be expected, this freeing of the orange-groves from one of the greatest pests with which they were ever infested removes a great burden from the shoulders of our orange-growers; or, as one of them, Mr. A. Scott Chapman, writes to me: "They have taken more than an oppressive burden off of the orange-growers' hands, and I, for one, very much thank the Division of Entomology for the *Vedalia cardinalis*—the insect that has worked a miracle."

One of the most important results obtained by me the past season has been the discovery of a method whereby trees could be treated with hydrocyanic acid gas at a price scarcely exceeding one-third of what it has heretofore cost by the old method. As the great expense attending the use of this gas has been the one great objection to its being universally employed for the destruction of scale-insects infesting trees, this objection having been now overcome we may naturally expect to see this method coming into more extended use than has been the case heretofore. As I have

given a full account of this new discovery in the report which follows, it will be needless to more than call your attention to it in this place. *

As heretofore, I am indebted to yourself for suggestions and other help.

Respectfully, yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
U. S. Entomologist.

RESIN SOAPS AND COMPOUNDS FOR THE DESTRUCTION OF THE RED SCALE.

Early in July of the present year I received a letter from Mr. L. O. Howard, acting entomologist during the absence of Professor Riley, instructing me to obtain permission from some person owning a number of large-sized orange trees which were thickly infested with the Red Scale (*Aspidiotus aurantii* Maskell), and then have the trees sprayed with one of the most approved resin sprays obtainable, the spraying to be repeated as often as would be found necessary in order to practically free the trees of these pests, or at least to prevent them from becoming so numerous as to interfere with the healthy growth of the trees, the object sought for being to demonstrate that citrus trees badly infested with these pests can be cleaned and kept in a healthy, growing condition by the use of the resin spray.

Before entering upon this work I concluded to make a series of preliminary tests with various preparations, containing resin and other ingredients in varying proportions, with a view of ascertaining the best and most desirable preparation to use in my field work referred to above. Accordingly I went down to Orange, in the adjoining county, which bears the same name, and, on the 17th, 18th, and 19th of July, made fourteen tests with various preparations, repeating one of these and making several additional tests on the 7th and 8th of the following month. The one giving the best results was used a trifle too strong, as I subsequently ascertained that it produced a discoloration on the underside of some of the oranges, or where they came in contact with each other or with a leaf or branch. For this reason a slightly weaker solution would produce better results, and doubtless the following proportions will be found the most effectual to use during the hotter part of the year:

Resin.....	pounds..	18
Caustic soda (70 per cent. strength)	do.....	5
Fish oil.....	pints..	2½
Water to make.....	gallons..	100

The necessary ingredients are placed in the boiler and a sufficient quantity of cold water added to cover them; they are then boiled until dissolved, being occasionally stirred in the mean time, and after the

* This portion of Mr. Coquillett's report has been published in advance in INSECT LIFE, Vol. II, double No. 6 and 7 (January and February 1890).—C. V. R.

materials are dissolved the boiling should be continued for about an hour, and a considerable degree of heat should be employed so as to keep the preparation in a brisk state of ebullition, cold water being added in small quantities whenever there are indications of the preparation boiling over; too much cold water, however, should not be added at one time, or the boiling process will be arrested and thereby delayed, but by a little practice the operator will learn how much water to add so as to keep the preparation boiling actively. Stirring the preparation is quite unnecessary during this stage of the work. When boiled sufficiently it will assimilate perfectly with water and should then be diluted with the proper quantity of cold water, adding it slowly at first and stirring occasionally during the process. The undiluted preparation is pale yellowish in color, but by the addition of water it becomes a very dark brown. Before being sprayed on the trees it should be strained through a fine wire sieve, or through a piece of swiss muslin, and this is usually accomplished when pouring the liquid into the spraying tank, by means of a strainer placed over the opening through which the preparation is introduced into the tank.

The preparing of this compound would be greatly accelerated if the resin and caustic soda were first pulverized before being placed in the boiler, but this is quite a difficult task to perform. Both of these substances are put up in large cakes for the wholesale trade, the resin being in wooden barrels, each barrel containing a single cake weighing about 375 pounds, while the caustic soda is put up in iron drums containing a single cake each, weighing about 800 pounds. The soda is the most difficult to dissolve, but this could doubtless be obviated by first dissolving it in cold water and then using the solution as required.

It has been very generally supposed that the finer the spray could be thrown upon the tree the better would be the results obtained, but after conversing with several persons who make the spraying of trees their special work I was somewhat surprised to learn that each of them were in favor of a rather coarse spray. In nearly every instance they had started out with the impression that a fine spray was the best, but had gradually adopted one somewhat coarser, finally adopting one that threw a moderately coarse spray with considerable force. After carefully investigating the subject I found that their reasons for preferring a rather coarse spray to a fine one were well founded.

The object sought for is not so much to simply sprinkle and wet the tree as it is to paint or varnish it over with the compound used, and this can best be accomplished by the use of a rather coarse spray, which enables them to throw the liquid upon the tree with considerable force, so that when it strikes any portion of the tree it spreads out and covers the adjoining parts with a thin film, as if put on with a brush. It also strikes many of the leaves with such force as to cause them to expose to the spray portions of their surfaces that would otherwise escape. Besides this, by the use of a moderately coarse spray the tree can be

wet or varnished over in a much shorter space of time than when a finer spray is used, and all of the operators that I have conversed with on this subject were unanimous in their statements that the time thus saved much more than compensated for the somewhat larger quantity of the preparation that was required when the coarse spray was employed as compared with a finer spray. The evidence, therefore, appears to be decidedly in favor of a rather coarse spray.

But whatever may be the character of the preparation used, or the nature of the spraying nozzle employed, the success of the operation will depend very largely upon the thoroughness with which the preparation has been applied. In the case of small trees it is comparatively easy to wet every part of them, but when the trees are 20 feet or more in height and have not been properly pruned it is not only difficult but quite impossible to wet every portion of them; and, unfortunately, the tendency is to use as little of the preparation upon the tree as is absolutely necessary. On tall trees the operation of spraying is made more effectual by the use of tall ladders, so that the various parts of the trees can be sprayed from above as well as from below.

It is well known among those who have had any experience in trying to destroy the Red Scale with sprays of any kind that the scale insects which are located upon the fruit are less affected by the different liquid preparations than those located upon the leaves or bark. The reason for this appears to lie in the fact that those located upon the fruit, having an abundance of food always within easy reach, are more healthy and vigorous than those located upon the other parts of the tree, and consequently are better prepared for resisting the destructive effects of the spray. That healthy, vigorous insects are capable of resisting the effects of a destructive agency that has proved fatal to their less vigorous comrades there can be no doubt. An instance of this kind is given in my report to Professor Riley for the year 1888, as published in the Annual Report of this Department for that year. On page 128, in speaking of the effects of arseniuretted hydrogen gas upon the Fluted or Cottony-cushion Scale (*Icerya purchasi*, Maskell), the statement is made that "Subsequent experiments made upon perfectly healthy trees and insects showed that when the gas was used strong enough to have proved fatal to all of the *Icerya* on the neglected trees it did not kill one-half of those on the vigorous trees." Owing to this fact it would be advisable to refrain from irrigating and cultivating infested orange trees for several weeks before spraying them, were it not for the other fact that in the case of bearing trees such a course would seriously interfere with their bearing qualities or operations. Unlike deciduous fruit trees, our citrus trees do not take a rest of several months' duration between the ripening of the fruit and the blossoming of the trees for another crop; only a few weeks at the most intervening between these two periods in the case of orange trees, while on healthy bearing lemon trees both blossoms and fruit are to be found at every season of the year.

In the case of bearing orange trees it would appear that the season of the year when they could be sprayed with the least amount of injury to themselves and with the greatest fatality to the red scales infesting them would be at a time when they were in blossom, after all of the fruit of the preceding season had been removed from them. There would at such a time be no fruit on the trees for the scale-insects to locate upon, so that all these insects that could be reached by the spray would be destroyed without at the same time injuring any portion of the tree. Several persons who had sprayed their orange trees at a time when the latter were in full bloom informed me that to all appearances none of the blossoms were injured by the spray, providing that the latter was not used so strong that it injured the leaves, being unanimously of the opinion that the blossoms were as hardy as the leaves. The young fruit is much more susceptible to the effects of the spray than are either the leaves or the blossoms, and this is the case until it becomes at least half-grown. It has been my experience, and also the experience of others with whom I have conversed upon the subject, that where the conditions are equal an orange tree is more susceptible to the effects of a given spray than a lemon tree, the foliage of the latter being hardier; whereas in the case of frosts the reverse of this is true, lemon trees being greatly injured by frosts that would produce little or no effect upon orange trees growing under similar conditions.

It is a well-established fact that any given spray will not be so fatal to the scale insects during the cooler portion of the year as it will if applied during the hotter portion. On this account it will evidently be found necessary during the winter months to use a somewhat stronger solution than indicated in the formula given above; and probably the proper proportions to use during this season would be obtained by adding water sufficient to make only 80 gallons, instead of 100 gallons as given in the above formula.

What is true in regard to the effects of the solution upon the insects is equally true of its effects upon the tree, the same solution that would not injure the tree if applied during cool weather might injure it very severely if applied during very warm weather. As bearing upon this subject, I can not do better than to give the experience of one of my correspondents, Mr. F. G. Ryan, an intelligent orange-grower of Anaheim, in the adjoining county of Orange. Mr. Ryan used the resin compound quite extensively for the destruction of the Black Scale (*Lecanium oleæ* Bernard), and under date of February 7, 1889, he writes me as follows:

I want to tell you of a disappointing experience I had with the resin compound. On January 21 and 22 I sprayed twelve trees in one quarter of the grove and eight in another with a compound composed of 1 pound of caustic soda, 8 pounds of resin and 32 gallons of water. After doing this a hot, drying wind arose and stopped our work. The wind continued for several days, becoming milder each succeeding day, and on the fourth day I noticed some leaves dropping from these trees; this dropping of the foliage has continued and increased until now there is scarcely half the foliage left

on two or three of the trees, and the others show a loss of from 15 to 50 per cent. I argue that as the trees first sprayed show a lesser loss than the others, the probabilities are that the water and compound were not thoroughly mixed, and as it is my custom to keep the inlet pipe of the pump near the top of the solution to avoid the sediment, these trees received a weaker solution, as the compound would remain at the bottom of the tank until thoroughly mixed and suspended in the water. No conditions of health of trees or soil affected the loss of foliage, since similar results are shown by the trees in the other part of the grove. My conclusion is that the cause exists in too strong a solution, followed by hot, dry winds for several days. Since the date of spraying there has been no rain nor even a fog or cloud until two days ago. I am happy to say, though, that the bugs are dead.

That this disastrous result to the foliage was the direct effect of the hot drying wind appears to admit of no doubt, since Mr. Ryan informs me that when no such wind prevailed he had sprayed a large number of his orange trees with a compound made precisely like the one used above, and the trees thus sprayed dropped scarcely a leaf. The fact that the latest trees sprayed suffered the most indicates not so much that they were sprayed with a stronger solution than the others, but rather that being sprayed later and being still wet with the solution they would naturally be more affected by the hot winds than those which were sprayed earlier, and from which the surplus solution had had time to drip off, while the remainder would be quite dry before the hot wind occurred.

Following is an account of a number of experiments which I made with various resin compounds and resin soaps for the destruction of the Red Scale (*Aspidiotus aurantii* Maskell); they were made at Orange, in the adjoining county of Orange, upon trees kindly placed at my disposal by Mr. H. F. Gardner. The trees in experiments 181-194 contained no fruit, but there were green oranges on all of the other trees experimented upon.

In making each of these solutions the necessary ingredients were placed in the boiler, covered with water, and boiled briskly from two to three hours, after which they assimilated well with water; the solution was then diluted with the proper quantity of water, strained through a piece of barley sack, and then sprayed upon the tree. In each instance only a small quantity of solid or semi-solid matter was strained out of the different solutions. An exception to this occurs in experiments 185 and 186, in which the resin was simply dissolved in water over a hot fire, after which the necessary quantity of water was added and the solution strained, as described above. In dissolving the resin I used 3 gallons of water for each pound of the resin; at first I tried to dissolve it at the rate of 1 pound of resin to 2 gallons of water, but a portion of the resin would not dissolve until more water had been added. The solution was of a milky-white color, and assimilated well with water.

The cost per 100 gallons of the different preparations as given below is based upon wholesale prices of the different ingredients, furnished me by the Los Angeles Soap Company, of this city. The rate on resin is by the 10-barrel lot of 375 pounds per barrel; of caustic soda, by the

drum of 800 pounds; of fish-oil, by the barrel of 50 gallons; of potash, by the cask of 700 pounds; and of tallow, by the barrel of 375 pounds.

(181) Resin, 25 pounds; caustic soda, 3 pounds; water to make 100 gallons; costs 65 cents. The diluted solution was of a light brown color. Sprayed on an orange tree at 11.30 a. m., July 17, sun shining, light breeze. August 6, foliage uninjured; found a great many live scales.

(182) Resin, 33 pounds; caustic soda, 4 pounds; water to make 100 gallons; costs 84 cents. Sprayed on an orange tree at 11.45 a. m., July 17, sun shining, light breeze. August 6, foliage uninjured; found great many live scales.

(199, 200) Resin, 25 pounds; caustic soda, 6 pounds; water to make 100 gallons; costs 77 cents. Sprayed on two orange trees at 10.45 and 11 a. m., August 7, sun shining, light breeze. September 2, found great many live scales, especially on the fruit; leaves uninjured; many of the half-grown oranges have rusty, brownish spots on their under sides, or where they came in contact with each other or with a branch or other object. These spots were still present October 19, but whether they will disappear or not before the fruit ripens remains to be seen.

(201) Resin, 33 pounds; caustic soda, 8 pounds; water to make 100 gallons; costs \$1. Sprayed on an orange tree at 11.15 a. m., August 7, sun shining, light breeze. September 2, same as in the preceding experiment.

(190) Resin 16 pounds, fish-oil 6 pints, caustic soda 6 pounds, water to make 100 gallons, costs 85 cents. The diluted solution was of a very dark brown color. Sprayed on a lemon and orange tree (*i. e.* orange budded to lemon, but the orange branches not cut away) at 1:30 p. m., July 18, sun shining, light breeze. August 6, leaves and newest growth uninjured; found ten live scales.

(191) Resin 22 pounds, fish oil 1 gallon, caustic soda 8 pounds, water to make 100 gallons; costs \$1.15. Sprayed on an orange tree at 2 p. m., July 18, sun shining, light breeze. August 6, a few of the older leaves have brownish spots on their under sides; found three live scales.

(192, 195) Resin 20 pounds, fish oil 3 pints, caustic soda 6 pounds, water to make 100 gallons; costs 80 cents. Sprayed on a lemon and on an orange tree at 1 and at 12:10 p. m., July 19, and August 7; sun shining in the first, cloudy in the second experiment, light breeze. August 6, in first experiment leaves uninjured; found two live scales. September 2, in second experiment leaves uninjured; found 12 live scales on the fruit and 8 on under side of the leaves where they had evidently escaped the spray. In both experiments the fruit was as described in experiment 199 above, but to a less degree.

The formula in these two experiments was the same, except that in 192 one pound more of the resin was used than in 195; but this small quantity in 100 gallons could scarcely have affected the results. This is the same formula used on September 3 of the present year (1889) for spraying twenty-five orange trees, in accordance with instructions

from Mr. Howard, referred to above. Two of the trees were 5 feet tall by 4 in diameter, while the others ranged from 14 to 18 feet tall by from 12 to 16 feet in diameter. They were sprayed between the hours of 3 and 5.30 p. m.; sun shining, light breeze. Three hundred gallons of the diluted compound were used. A tree 16 feet tall by 14 feet in diameter required about 14 gallons of the compound, and three men and a spraying outfit will spray about 800 gallons in a day. The cost of materials and labor in spraying with this compound a tree of the size indicated above amounts to about 24 cents per tree. I examined the above-mentioned trees September 24, and again October 19, and found that the leaves and fruit were uninjured, but a few of the oranges had small brown spots on them as described above in experiment 199. Nearly all of the scales located on the leaves and bark were dead, but about one-fourth of those located upon the fruit were still alive.

(193, 196) Resin 28 pounds, fish oil 4 pints, caustic soda 8 pounds, water to make 100 gallons; costs \$1.10. Sprayed on two orange trees at 1.15 and 12.20 p. m., July 19 and August 7; sun shining in the first, cloudy in the second, light breeze. August 6, September 2, and October 19, leaves uninjured; some of the oranges had brown spots on them as described above in experiment 199; found only one live scale on the leaves, and three on the fruit.

(202) Resin 21 pounds, fish oil 3 pints, crude potash 4 pounds, water to make 100 gallons; costs 85 cents. Sprayed on an orange tree at 12.30 p. m., August 8; sun shining, light breeze. September 2, leaves uninjured; some of the oranges had brown spots on them as described above in experiment 199; found many live scales both on the leaves and fruit.

(203) Resin 28 pounds, fish oil 4 pints, potash $5\frac{1}{2}$ pounds, water to make 100 gallons; costs \$1.15. Sprayed on an orange tree at 1 p. m., August 8; sun shining, light breeze. September 2, same as in the preceding experiment.

(183) Resin 20 pounds, tallow $6\frac{1}{2}$ pounds, caustic soda $6\frac{1}{2}$ pounds, water to make 100 gallons; costs 98 cents. Sprayed on a lemon tree at 12 m., July 17; sun shining, light breeze. August 6, a few of the older leaves were injured; found great many live red scales.

(184) Resin 25 pounds, tallow 8 pounds, caustic soda 8 pounds, water to make 100 gallons; costs \$1.22. Sprayed on an orange tree at 12.30 p. m., July 17; sun shining, light breeze. August 6, leaves uninjured; found three live red scales.

(188) Resin 17 pounds, tallow 6 pounds, caustic soda 6 pounds, water to make 100 gallons; costs 88 cents. Sprayed on an orange tree at 1 p. m., July 18; sun shining, light breeze. August 6, leaves and newest growth uninjured; found twelve live red scales.

(189) Resin 22 pounds, tallow 8 pounds, caustic soda 8 pounds, water to make 100 gallons; costs \$1.16. Sprayed on a lemon tree at 1.15

p. m. July 18; sun shining, light breeze. August 6, leaves uninjured; found fourteen live red scales. The pupae and recently transformed adults of the Chalcid fly, *Dilophogaster californica* Howard, which infested fully 80 per cent. of the black scales (*Lecanium oleae* Bernard) on this tree, were all of them destroyed by this spray.

(187) Resin $2\frac{3}{4}$ pounds, tallow 14 pounds, crude potash $5\frac{1}{2}$ pounds, water to make 100 gallons; costs \$1.10. Sprayed on a lemon tree at 4.30 p. m., July 17; sun shining, light breeze. August 6, leaves uninjured; found three live red scales.

(185) Resin 19 pounds, water to make 100 gallons; costs 38 cents. Sprayed on an orange tree at 4 p. m., July 17; sun shining, light breeze. August 6, leaves and newest growth uninjured, but few of the red scales were destroyed.

(186) Resin 22 pounds, water to make 100 gallons; costs 44 cents. Sprayed on a lemon tree at 4.15 p. m., July 17; sun shining, light breeze. August 6, same as in the preceding experiment.

EFFECTS OF THE EUREKA INSECTICIDE ON THE RED SCALE.

On the 1st of August of the present year I received a letter from Acting Entomologist Howard, dated July 25, 1889, requesting me to make a test of the "Eureka Insecticide," put up by E. Bean, of Jacksonville, Fla., who would forward me a few sample cans of the insecticide for this purpose. These samples reached me in due time, and I carefully tested the preparation according to directions. One pound of it was emptied into a vessel, 6 gallons of cold water added, and the whole frequently stirred. After the lapse of one hour I allowed the insoluble portion to settle to the bottom of the vessel, poured off the clear liquid portion, and sprayed it upon an orange tree at 2 p. m., August 7; cloudy, light breeze. September 2 the leaves were uninjured, and I could not discover that any of the red scales (*Aspidiotus aurantii* Maskell) that were encased in a scale or shell at the time the application was made had in the least been affected by the spray.

In a circular received from the proprietor it is stated that this insecticide is sulphur in solution, a patented process, and that it "is absolutely fatal to the rust mite, and also to the scale insect during the breeding or migratory periods," providing that the applications extend through the entire season. It is possible that this insecticide would prove fatal to the recently hatched red scale, but as this becomes covered over with a shell inside of twenty-four hours after leaving the parent, and as the young ones appear during almost every day in the year, it follows that in order to be effective it would be necessary to apply this insecticide every day for three or four months consecutively—a task which very few of our fruit-growers would be willing to perform.

REPORT ON INSECTS OF THE SEASON IN IOWA.

By Prof. HERBERT OSBORN, *Special Agent.*

LETTER OF TRANSMITTAL.

IOWA AGRICULTURAL COLLEGE,
Ames, December 11, 1889.

SIR: I beg to submit herewith my report upon the season's observations and study for 1889.

I have during the season made a series of tests of X. O. Dust under directions from your office; reports of which were transmitted immediately on completion of the tests, and have continued to work, conjointly with yourself, on the insects affecting domestic animals. As bearing upon the same general subject, and connected with one of the most important industries of the State, and, indeed, of a large part of the United States, I have given such time as I could to the study of insects affecting meadows and pastures. Believing, however, that more could be accomplished by giving attention to some particular group, and considering the great importance of the Leaf-hoppers and other Homoptera, and the fact that they have been but slightly studied in this connection, I have spent most of the time upon this group.

The study of these is rendered more difficult in consequence of the great number of species as yet undescribed, and the lack of any complete literature upon known American species. But for these very reasons there is the more need of their being investigated. My results seem meager for the time devoted, but I believe that with the material now brought together much more rapid progress can be made in future studies.

Thanking you for the many favors received from your office, I am
Very respectfully,

HERBERT OSBORN.

PROF. C. V. RILEY,
U. S. Entomologist.

GENERAL OBSERVATIONS.

While no wide-spread devastation has occurred in the State during the past season there has been a considerable amount of damage from a number of different species affecting various crops and operating in different parts of the State.

Cut-worms of different species were unusually abundant, and I received specimens and inquiries regarding them from different parts of the State. They were quite troublesome in gardens, nurseries, and fields in this locality.

The Turf Web-worms (*Crambus exsiccatu*s), reported on in detail two years ago, were again quite abundant, but not so numerous or destructive as in 1887. An allied species (*Crambus laqueatellus*) was quite

abundant in the adult form in the latter part of May, and there is good reason to believe that the larvæ have the same destructive habit in grass, and, from the occurrence of the imago so early in the season, it would seem probable that as in *arsiccatus* there are two broods each season.

Another moth nearly related to these web-worms occurred this season in great numbers in pastures and meadows, and though I have not had opportunity to study the larval stage, it may be well to call attention to it as a probable grass pest that may prove as troublesome as the species of *Crambus*. This is the *Nomophila noctuella*, and it was noticed in greatest abundance from May 18 to 22 (1889). The species has been observed as abundant in previous seasons and is probably a pretty constant inhabitant of grass land.

During the latter part of May and first part of June the Blue Grass in the vicinity suffered from the trouble called "Silver Top," the head and upper joint of the stalk turning whitish. I examined a number of these withered and partly wilted stalks and in a few cases found *Thrips* present, and in some cases swollen joints appearing as if affected with *Meromyza*, the adults of which were very plentiful on grass a little earlier. If due to *Thrips*, I think they must leave the grass almost as soon as it begins to wither, as in the cases where I found them I selected stems that were just beginning to turn white.

The Clover-seed Midge has appeared in this State, and the present year is the first I think that it has been destructive. It has been reported in a few localities and I swept the adults from clover in considerable numbers May 25. A very few were bred from clover heads in 1888.

Epitrix cucumeris was very abundant on potatoes, but as the vines had a very vigorous growth in the early part of the season no serious damage resulted.

Diabrotica vittata and *D. 12-punctata* were exceedingly plentiful and furnished me material for some tests of X. O. Dust hitherto reported. I also tried for these a mixture of London purple and kerosene emulsion for the purpose of killing the beetles gathered on the squash vines and preventing the complete destruction of foliage, depending upon the London purple to kill the beetles gathering on the vines later. After this application the vines did very well and I think the plan a success. The beetles will, some of them, fly away before the kerosene takes effect, but they probably all die in a short time. I have since noticed that Prof. John B. Smith has used a similar plan for treating the Elm-leaf Beetle, and it would seem to be applicable in many cases where the expense is not an obstacle and where it is desired to kill the bulk of the insects gathered on plants before they have time to destroy foliage, which they must do to some extent when treated with London purple.

Plant lice of many species were abundant in the latter part of the season. Of these the Thorn-tree Aphid (*Schizoneura eratagi* Oest.) was especially conspicuous by its abundance on thorn trees. The common

Willow-Plant-louse (*Melanthus salicis*) was brought or sent me a number of times, showing that it attracted unusual attention, and the eggs deposited by the oviparous females were to be found in numbers under the buds of willow twigs in late autumn. Of all the species noticed, however, the swarms of the Dogwood Aphid (*Schizoneura corni* Fab.) were most remarkable. This species is referred to more particularly in another place.

OBSERVATIONS ON INSECTS AFFECTING GRASSES.

The importance of the pastures and meadows in this State will be conceded by every one familiar with its agriculture. Perhaps no other single element is of greater importance, furnishing, as it does, the basis for the stock industry of the State.

The insects infesting meadows and pastures are therefore of the greatest importance, and while their depredations are perhaps less conspicuous than those from insects affecting some other crops, I think it can be clearly shown that the average annual loss in pastures and meadows from insect injuries is equal to if not greater than the crop harvested or the amount consumed by cattle, horses, or sheep in pasture, and probably furnishing a total annual loss greater than in any other crop. In ordinary pasturage it is common, I believe, to allow two acres of land to each cow, or, for convenience, let us say that one acre will half support a cow. At the same time that this cow is feeding there are a million insects, more or less, of various kinds feeding upon the same area by day and night from the time the snow melts in spring till winter forces them to suspend their work.

The only compensation they can offer is that when dead (and they die young), their million little carcasses dropping on the surface of the soil return to it some of the material which has been built into their tissues, increasing its richness and helping to support succeeding generations.

In my report upon the Turf Web-worm two years ago, I gave the count of burrows that had been opened by squirrels as twenty-five in one instance and fifty in another, within a square yard, and it is not probable that every burrow within those areas had been opened by squirrels. The web-worms were, however, uncommonly abundant that season. If we reduce the mean of these figures by one-half and allow two web-worms to each square foot it means 87,120 to the acre, and then consider that these worms eat down quantities of grass that they do not devour, it would seem hardly too much to suppose that these alone would prove a pretty even match for one half a cow in disposing of the grass growing on an acre.

All are familiar with the depredations of white grubs, and it is hardly necessary to ask whether in seasons when these are plentiful they do not destroy as much or more than would support at least half a cow.

Cutworms and Army worms are a constant source of loss in grass

land, and these with the grasshoppers, familiar to everybody, are capable of mowing down a quantity of grass during a season which ought to be appreciated by the farmer. Grasshoppers need not be remarkably plentiful to place a dozen to a square yard, over 50,000 to the acre, and is it any wonder that pastures run short in seasons when rain is scarce or grasshoppers a little more plentiful than usual?

The kinds of insects so far mentioned perform their work in a way that causes an actual lessening of bulk in the crop, but there is another host, less noticeable in size as well as in method of work, whose actual damage in reduction of available food for stock must be of very great importance. These, like the Chinch Bug, which is one of their number, simply puncture the leaves or stems of the grass and pump out its juices, thereby abstracting much of the best food material even where they do not cause a checking of growth and shriveling of the plants. Many of these are insects of very minute proportions, but like the Chinch Bug make up in numbers for their diminutive size. It is no exaggeration I think to say that they occur by the million to the acre.

A million mouths against a half a mouth, and is it necessary that the individual mouth be a very large one to make the aggregate food consumed equal that of the half cow?

In order that my figures may not seem purely fanciful, I may state that they are derived in part from actual count, but in all cases, when count has been made, the circumstances have been such as to make the numbers fall short of the actuality.

I have captured leaf-hoppers on grass by throwing a net down vertically and counting the number caught within the area inclosed by the ring, and while it is hardly possible in this way to secure all that were actually within that area the average of a number of such captures gives nearly a million to the acre.

I have many times observed them when plentiful and tried to count the number within a given area, but their activity makes this difficult. By approaching them very slowly and keeping very quiet, I have on some occasions been able to observe them closely and have on different occasions been able to count many within the area of a few square inches; often two or more to a single blade of grass, and consequently I feel satisfied that the estimate based on the numbers captured are far below the actual numbers frequently occurring during seasons when they are ordinarily abundant and greatly under the number in seasons when they have multiplied to any unusual degree. It may perhaps be urged that, even allowing them to abound in this degree every season, they are too small to consume a very great amount of food. Possibly a million leaf-hoppers would not exceed in bulk the half of an average cow, but it should be remembered also that they grow very rapidly and must consequently use proportionately large quantities of food, and that they extract the most nutritious parts of the grass. That grass forms the bulk of their food has not I think been questioned, but to be certain on

this point I have observed them carefully and examined with particular care the grass blades on which I have seen them established.

On September 7, 1889, I swept grass where no other living plants were to be seen and collected numerous Hemiptera of a number of different species, mostly Homoptera. The grass was very dry, brown, and in many places appearing dead, but evidently still furnishing support for the leaf-hoppers. There were but few other insects present, scarcely any that could be supposed to feed upon grass, except some grasshoppers (*Caloptenus femur-rubrum*, species of *Edipoda*, etc.). The species of Homoptera collected may I think be considered as unquestionably grass feeders. No other vegetation that could furnish them support had been on the ground swept for weeks, and the insects swarmed on every square foot. The grass commenced turning brown in patches long before it should be expected to, if affected only by want of rain, as it showed within a short time after the last rains, which had been quite regular and copious, previous to the dry period of that time, and its drying up must have been hastened by losses due to the presence of insects. The ground was not yet dry enough so that the grass could have suffered from lack of moisture alone. Their presence on grass seems to show its effect in two ways, though for one of them it is difficult to draw the line between the effects of leaf-hoppers and dryness. In one the effect of punctures shows in numerous pale and dry spots on the blades of grass resembling effects produced by related Homoptera on other plants, apple-trees, pear-trees, grape-vines, etc. Such spots can not be found, however, in such numbers as would be expected if there were one for every puncture by the millions of these insects that occur in every piece of grass land. But the great bulk of the grass is withered or dead down to a certain point near the ground (or to the ground), which would naturally be the appearance if the leaf withered from the lower punctures to the tip, thus obliterating all punctured spots on the terminal portion.

The difference between grass withering from punctures and from lack of moisture is perhaps not sufficiently different to furnish a very safe basis for deduction, but in the latter case it is naturally more gradual and holds for a longer time the green color of hay, so that for withered grass not too long exposed I believe we should be able to distinguish in some degree the difference between that killed by leaf-hoppers and that dried by excessive heat and lack of moisture in the ground.

While this may fall short of actual demonstration, I think a careful study of the effects in the field will convince any one that my conclusions are justified by the facts and that, taking year after year, the amount of injury caused by insects of various kinds is fully equal to the amount consumed by the stock ordinarily pastured on the same land. It is evident, then, that the prevention or the reduction of the insect injuries would add an equivalent amount to the return from such land. Instead of one cow requiring two acres for pasturage, pastures comparatively free

from insects should support a cow to each acre through the entire season. It is certain that much of this loss can be prevented by simple and inexpensive means. The capturing of the moths of Turf Web-worms and Cut-worms will help much in reducing their number. Grasshoppers can be destroyed at the same time that Leaf-hoppers are, and by use of the same means, and it would seem certain that a method costing but 2 to 10 cents per acre might be applied with great profit for these insects alone. It is my object here, however, to treat in detail only of the remedies tried or proposed for Leaf-hoppers.

APPEARANCE AND HABITS OF LEAF-HOPPERS (JASSIDÆ).

The insects embraced in this group are almost all small and rather slender insects, with blunt or pointed heads and well-developed wings, which at rest lie parallel along the back, usually sloping like a roof, or partly inclosing the body. One of the most characteristic features, however, is their habit of leaping when disturbed. All the species possess this habit, though some do not leap as readily as others. The largest species common to grass are not over half an inch in length, while the smaller ones are less than an eighth of an inch long. Many of the species are extremely light and slender, almost invisible except when carefully observed, while others have short, thick bodies. Their colors are well adapted to furnish them protection, many being green, others yellowish or brownish, and in many cases they will not be noticed at all on the grass until they leap, and then it is usually because of the swarm that rise together that they become noticeable. All feed by puncturing the plant and sucking out the juicy contents of the leaves or stems. All, so far as known, puncture leaves or stems of plants to deposit their eggs, frequently placing them under the epidermis only. The larvæ are commonly somewhat spiny at first and have the general form of the adults, passing by gradual development with little change through pupa stage to adult. Most of the species, if not all, pass the winter as adults.

REMEDIES FOR LEAF-HOPPERS.

Burning.—For those species of leaf-hoppers which hibernate in grass, and especially those which are active there during late fall and early spring, a thorough burning over should prove of great advantage. The Leaf-hoppers leap readily, but do not ordinarily fly any distance, and especially when the weather is cool would be unable to escape from the flames. In two pieces of grass land burnt over last spring and convenient for observation one showed fairly good results, keeping its color well till late in summer, though surrounded by grass land, unburnt, on three sides. The other, a pasture of some size, was in poor condition all summer; but in this Turf Web-worms and Cut-worms were so plenty that they alone were sufficient to account for its poor condition.

Plowing.—There seems little ground for hoping that the number of Leaf-hoppers can be diminished materially by any system of plowing under, or by rotation of crops. Grass is an essential on every farm, and no system of starvation could be adopted, and even if deprived of the common pasture grasses, the most of the species evidently thrive on the fox-tails and other grasses that flourish as weeds. The leaf-hoppers are too active to be plowed under and can readily migrate to other fields. Eggs for most of the species, at least, are not deposited at any fixed time of the year, and while by plowing under in May, June, or August many eggs might be buried, plenty of hoppers would escape to the surrounding grass land to keep the farm well stocked.

Mowing.—When the grass in which Leaf-hoppers have been very abundant is cut short, leaving only a dry stubble, the insects seem to be forced to migrate, as few or none can be found in such places a few days after the cutting nor until a new growth gives them a source of fresh food supply. While early cutting of meadows badly infested might result in saving a larger crop, it must follow that the Leaf-hoppers would travel to pastures or other grass land, and it would be simply a question as to where they would do the greater amount of damage. It would seem feasible, however, to take advantage of the time when the crop has been just removed to use hopper dozers or other means for capturing them before they have left for fresh pasture. We know, as yet, too little as to where and when the bulk of the eggs are deposited to say whether cutting at any particular time would result in the destruction of any number of eggs. While we know that Leaf-hoppers deposit eggs in stems and leaves of plants, we are not acquainted with their full history or the methods of different species, so that it would be unsafe at present to base remedies on this part of their history.

Capturing in Nets.—The ease with which all species of leaf-hoppers affecting grass can be taken in sweep-nets led me to try the use of this principle on a larger scale. I therefore had a couple of wire frames made 3 feet long, fastened a deep cheese-cloth net to each and attached these to two long handles, so that the frame of one would brush the ground about a foot behind the forward one. The object of having two nets was to secure the hoppers which allowed the first wire to pass over them before leaping. With the handles the net was pushed forward so that the insects were not disturbed till the approach of the net and a strip of ground a yard wide was gone over either at a walk or a run. While numerous insects were secured by this plan, Grasshoppers, Moths, Clover-seed Midges, and large numbers of Leaf-hoppers, the count of those secured from the nets showed that as compared with what must actually exist on the same ground as shown by other captures, only a portion of the Leaf-hoppers were thus secured, and considering the trouble of holding and destroying all the insects captured, I concluded that this plan was not equal to the hopper-dozer for this purpose. The second net captured a goodly number of insects as well as the forward

one and probably held them better, as they could not as readily fly out after having entered. It was found that more insects were captured when the net was pushed at a run than when walking. Probably even then many insects succeeded in flying out of the forward net.

Nets arranged in this manner, two or even three in succession, might be made eight or ten feet long and run by boys, one at each end. The forward net should be closed as soon as a stop is made, and the nets all closed at the finish, when they may be left a day or two for the insects to die. Usually there are enough predaceous species captured to kill the others rapidly, and such species could then be set free. Many species of insects beside the Leaf-hoppers are caught by this device, and some, such as the moths of Turf Web-worms, and Cut-worms, small Diptera, Clover-seed Midges, etc., that are not as apt to be taken in the hopper dozer.

Hopper Dozer.—This simple contrivance (a sheet-iron pan containing kerosene and water or coal tar, to be dragged over the infested ground), devised for the destruction of the Rocky Mountain Locust, possesses the essential qualities for the destruction of the Leaf hoppers as well. I believe that it can be used with profit in any pasture affected with these pests. The delicate Leaf-hoppers are killed by the kerosene almost the instant they touch it, and though my trials with it were made when the weather was so cool that the hoppers did not leap with their usual activity, they showed that it would operate successfully. It would be best, probably, to use it for these during warm days, when the insects are at their greatest activity, and early enough in the spring to catch the hibernating adults before they deposit eggs, repeating the operation, if necessary, in July, and for meadows immediately after the removal of the hay crop. Perhaps two pans, one behind the other, will prove advantageous.

The Shield Method.—A plan that is scarcely more than a modification of the above has been recently highly recommended for the destruction of the Leaf-hoppers infesting grapes. A quite similar plan was adopted for the destruction of the Rocky Mountain Locust years ago and is described in the first report of the United States Ent. Com.; and in his first annual report as State Entomologist of New York, Professor Lintner suggests its use for "low-feeding insects" "especially hopping species." I have not as yet tested it myself, but will give the plan, that others may test it for these insects if disposed. A piece of drilling or, what would be cheaper still, a strip of building paper is fastened to a light wooden frame and is coated with coal-tar or gas-tar, the residue from distilling off kerosene from petroleum, or from gas manufacture. In case of grape Leaf-hoppers this frame is held as near the vines as possible by one man, while another lifts the branches. The hoppers darting against the shield are caught and killed. For grass Leaf-hoppers the frame would be set on runners and could be made 10 to 15 feet long and run by a boy or man at each end. The best angle at which to

hold it would be soon determined by trials, and if sloping back it might be that the underside of the shield, if coated with the tar, would capture hoppers as well as the upper. As coal-tar can be secured in most towns at small expense, and as the frame for the shield costs but little, this method should be applied at a cost of not more than 5 to 8 cents per acre, and could be repeated two or three times during a season if either Grass-hoppers or Leaf hoppers become plenty.

It could be used in meadows or tall grass by mounting the frames on runners high enough so that the grass while being bent over should have plenty of room to pass under the shield, but would not be likely to work well when pollen is flying from the grass blossoms or when the seed begins to fall, as the tar would so soon become covered with the dust and chaff.

NATURAL ENEMIES OF LEAF-HOPPERS.

But little is known regarding natural enemies for these active little insects. I have found the common *Coriscus fesus* very plenty in all grass land examined, and where but few other insects were present to furnish it food. When left in nets with Leaf-hoppers the latter are soon found dead, while the *Coriscus* thrives, and knowing their very carnivorous habits, there can, I think, be no question as to their serving a useful purpose in killing these as well as other grass pests. As this species does not have the leaping habit it is less likely to be destroyed in "hopper dozers" than the hopping species, and consequently these remedies can be used with little danger of destroying this natural check to the multiplication of injurious species.

SPECIES OF LEAF-HOPPERS OBSERVED IN GRASS.

THE TENDERFOOT LEAF-HOPPER.

(*Dicrocephala mollipes* Say.)

This widely distributed species is perhaps the most abundant of its genus, and is unquestionably a source of much loss in pastures and meadows. Professor Uhler states its range as "Texas, Colorado, Mexico, and the southern part of the Atlantic region." It is one of the most abundant insects in the Upper Mississippi Valley, and I have found it in great numbers on blue-grass and on prairie grasses, where this must have been its principal, if not only, source of food. Other grasses would seem to serve it equally well. Professor Uhler says (Standard Natural History, vol. II, p. 249):

The salt marshes of the Atlantic States furnish places of shelter for it, where it may be found on reedy grasses in all stages from June till October.

That it prefers moist places is evidenced by its comparative scarcity on high ground in dry seasons, and its greater abundance in the vicinity of thickets as well as in low ground at such times. It is about one-

third of an inch long, of a bright grass-green color, the head and thorax above yellow. It varies considerably in size, and the females average considerably larger than the males. The head is sharply pointed, has a number of fine black lines on its upper surface; the face is shaded dark brown, and has a double series of transverse bars.

The larvæ which appear to be most common in early summer are light green or yellowish, and agree with the adults in having the head sharply pointed. I have found them most common in May and June, and, as adults are abundant from this time till autumn, it is difficult to say whether there is more than one brood. I have not seen adults in winter or early spring, and it seems possible that eggs in this and allied species are laid in fall to hatch in spring. As this would be contrary to the habit of the majority of insects in this family it will require further observation to establish it. It is at least quite certain that they do not hibernate as adults in grass, and unless eggs are deposited in stems of grass or other plants in grass land the insect can not be destroyed by burning in early winter or spring. It will be seen that there are important points to determine about this very common insect, and means of destroying it may depend in large degree upon the determination of some of the very simple steps in its life-history. It jumps readily, and like other members of the family may be treated on the "hopper-dozer" plan.

THE NEW YORK LEAF-HOPPER.

(*Diedrocephala noveboracensis* Fitch.)

This species is a little larger than the *mollipes*, but resembles it very closely. Its head, however, is less acute, and there are four distinct black spots on the front margin of the head, two of them close together at the tip and one each side in front of the eyes; the lower surface of the head lacks the brown color of *mollipes*, or is but faintly browned. Their habits appear to be much the same, and they are often found in the same locations, though I have found this species more commonly in the grass in wooded pastures or at the borders of thickets. I have never observed it in such abundance as I have the *mollipes*, and ordinarily it is probably of little importance. With equal numbers it would of course be as serious a pest as any of the other species of the family. Professor Uhler says it is common in many parts of the United States north of Maryland and it extends north into Canada and British Columbia.

(*Diedrocephala versuta* Say.)

This species bears a striking resemblance to *coccinea*, and has very similar habits, occurring in similar localities, and probably living upon the same plants. While Say's description was published in 1831 I know of no reference to the species in works on Economic Entomology, and

no reference that would indicate its occurrence in destructive numbers. It is introduced here as one of a group of insects whose importance will I believe be more appreciated when their habits become better known.

THE RED-BACKED LEAF-HOPPER.

(*Dicrocephala coccinea* Forster.)

So far as I have observed this is not an abundant species, and while evidently common throughout the United States I know of no record of its multiplying to numbers sufficient to make it destructive. I have found it usually in the vicinity of timber or thickets, and while it probably subsists on grasses does not select the open meadows or pastures but localities affording more moisture and shade. It is a handsome and conspicuous species, the upper surface when wings are closed being largely of a deep red color with dark blue or blue-green stripes. It was described under the name of *Cicada coccinea* by Forster (J. R.), in 1781 (Novae. Spec. Insect., p. 96), and afterward by Say as *Tettigonia quadrivittata*.

THE HIEROGLYPHIC LEAF-HOPPER.

(*Tettigonia hieroglyphica* Say.)

This was quite an abundant species the past season, but the majority of the specimens taken were found in the grasses of timber or among the low herbage along ravines, grassy banks, etc.

Professor Uhler says it "inhabits Texas, the foot-hills, and plains of Colorado from August to October, and the Atlantic region throughout." It is somewhat smaller than the *mollipes*, usually less than one-fourth of an inch in length; the head is rounded in front and marked with irregular black crescentic spots and bars. There is much variation in depth of coloring and extent of marking so that it is difficult to give a brief description that will be distinctive. While it was described in 1831 by Say, it has not been so abundant or noted as sufficiently destructive to get a place in the literature of economic entomology. Like many other of the species of this family, however, it has been lumped off with many of its relatives among the injurious leaf-hoppers, and hence should not be regarded as hitherto unmentioned among injurious species.

THE FOUR-POINTED AGALLIA.

(*Agallia quadripunctata* Prov.).

This species appears to be common throughout most of the United States, although I am not aware of its having been recorded as occurring in great abundance at any place. It is, however, one of the species which occurs in considerable numbers and does its share toward injuring the vegetation of pastures and meadows.

Whether it feeds mainly on grasses or attacks also the various plants growing with grasses I can not at present say, as it has not been studied in such connection as to determine this point.

It is about an eighth of an inch in length and of a yellowish-brown color with scarcely any decided markings except two black points on the front margin of the head and two similar points at the hind margin of the prothorax. These latter points are nearly in line with those on the head, though a little farther apart, so that the four points stand nearly at the corners of an imaginary square. Other points within the square are in some specimens quite distinct, but not so conspicuous as the ones described. The species appears to have been first described by M. Provancher (Nat. Can., IV, 376), in 1872, but it has quite generally been known among entomologists as *Agallia flaccida* Uhl. Mr. E. P. Van Duzee (Entom. Amer., V., p. 167) says:

This species I have received in exchange from a number of correspondents as *Agallia flaccida* Uhler, and have so used the name myself in exchanging and in the *List of Muskota Hemiptera*. It seems to have been an early manuscript name of Mr. Uhler.

But little can be stated regarding the life history of this species and there are probably no important differences between this and other species of the same family. Nearly all the specimens taken or observed have been mature, and without rearing it would be uncertain whether larvæ apparently of this species really belonged to it. Adults have been taken at different times of the year, and probably it can be found in this condition during each month of the year. Mr. Van Duzee says in the article quoted above that "this is a very abundant species in western New York from early in May until September, and in fact the year round, as it appears to hibernate in the adult state, as do many if not all the *Jassidæ*."

I have not found it in grass during winter, and can not say whether it hibernates mainly in pastures and meadows or seeks the shelter of dead leaves and rubbish in thickets, hedges, etc.

Agallia sanguinolenta Prov.

This little Leaf-hopper has been quite common in this locality during the last few years, and while never so abundant that it can be counted a serious pest in itself it must be counted in with related species in any enumeration which pretends to give the grass-feeding species. That it has a wide range is indicated by the following from Professor Uhler (Bull. U.S. Geol. and Geog. Surv., vol. II, p. 359 [93, of part], 1876): "This is a very variable little insect, which is not confined to the region of the Rocky Mountains, but which has been found likewise in Texas, in British Columbia, Canada, and New England."

It was described under the name of *Bythoscopus sanguinolentus* by M. Provancher in 1872 (Naturaliste Canadien, IV, 376) and in 1876 by Professor Uhler under the name of *Bythoscopus siccifolius*. Mr. E. P. Van

Duzee has, however, in the *Entomologica Americana* (V., 166) placed this latter as a synonym, and remarks:

Through the kindness of M. Provancher I had the pleasure of examining a typical example of his species and have thus been able to compare it directly with Mr. Uhler's description, and find that it agrees in every particular. It is not an uncommon species here (Buffalo, N. Y.) on grass and weeds in pastures and road sides, especially where *Carex* and *Juncus* abound.

It is a little smaller than the *quadripunctata* and rather broader in proportion, and is quite readily distinguished from that species by the dark wing veins and the more decided markings on the head and prothorax. It is scarcely an eighth of an inch in length and fully one-third as wide as long.

A dark form which differs from the typical ones, so far as I can see, only in the greater intensity of the markings is perhaps even more common here than the typical form, and this I have found fairly plenty and quite active in blue-grass lawn during the latter part of November, so that we may be pretty certain that it hibernates under grass and probably feeds more or less during mild weather of late fall and early winter. It can also be considered as quite certain that it can live exclusively upon grass, as in the localities where I have observed it it could scarcely have been depending on other vegetation for its food.

THE WAVY-SPOTTED LEAF-HOPPER.

(*Allygus irroratus* Say.)

The propriety of including this species in a discussion of grass insects may possibly be questioned, since its range of food plants is very great. There is no question, however, that plants of the grass family are among those most commonly affected by it, and I have found it abundant in grass land, where evidently this was its only source of food. It will be unnecessary, however, to detail its method of work, as it agrees so nearly with other members of the same family, and all methods of treatment must be based on similar principles. It may be stated, however, that there is as yet no evidence, so far as I knew, that it hibernates in grass, and therefore those remedies based on that habit in some of the species will not be applicable to this. Descriptions of the species were published by Say in 1831, and since that time the species has had frequent mention in entomological works, but only occasional reference to it as an injurious species is made, and in these references it is as often spoken of as a grain pest.

THE DESTRUCTIVE LEAF-HOPPER.

(*Cicadula exilis* Uhler.)

When attention was first called to this species it was from its attacks on wheat, but that it is of equal if not greater importance as a grass pest seems to me pretty clear after the observations of the present

season, and it would be interesting to know whether, in the reported destruction to wheat, this crop had not followed grass or whether the insects had not simply traveled from grass land. I have taken them in abundance from grass, and in blue-grass, where no other living plants were near, they occurred in large numbers, so that there would seem to be no question as to grass being their natural food. They have been reported as abundant and destructive on timothy in Missouri. (INSECT LIFE, Vol. I, p. 381).

They are about two-tenths of an inch in length, of a brownish color, and the wings are rather prominently marked with dark veins. It is an active species, jumps and flies readily, and is easily captured in a sweep-net, and would probably fall an easy victim to the "hopper dozer" or "shield," where these can be used.

It was described by Professor Uhler in the *American Entomologist*, Vol. III, p. 73 (1880), and a description and an account of its injuries to wheat in the Carolinas and Georgia occurs in the Report of the Department of Agriculture for 1879.

THE HURTFUL LEAF-HOPPER.

(*Jassus inimicus* Say.)

Of all the species of Homoptera that I have observed infesting grass this has been unquestionably the most abundant and constant in its depredations. It is *par excellence* a grass pest, and is found in great numbers in pastures and meadows at all seasons of the year, even in warm days of early winter, being found hopping actively about among the blades of grass and probably extracting some slight amount of food material even during this season. During the past season they have been especially numerous and destructive, or at least my attention has been called to them more frequently than before. My notes show them swarming in May, June, July, August, and September, and, recently, the latter part of November, and, later, December 12. I have found them scarcely less plentiful and active in the grass on blue-grass lawn. I observed them also in great numbers in all the pastures and meadows that I examined while in Linn County, in the eastern part of the State, in the latter part of June. Actual killing of grass by them is, however, a somewhat difficult matter to prove, and, except in seasons of unusual dryness, there is probably not sufficient withering of the grass from their presence to attract attention. In July and August grass here showed injury by turning brown in patches, and this commenced too soon after rains to be referred entirely to drought.

Later in the summer (September 7 and later), when the attacks of the leaf-hopper had caused most of the lawn to appear brown, such patches were not conspicuous. Examination of the grass where blades were not entirely withered would show in many cases brown spots of varying sizes, generally with the center on or near the midrib, and from small

spots of this kind all gradations of withering could be found up to where the entire blade was withered or brown. Plenty of these insects were to be found even where the grass was comparatively dry, but that they preferred the more juicy grass was shown by their accumulation in shaded places or where the grass presented more vigorous aspect. They could be secured in abundance from patches where no other vegetation occurred, and in the absence of other insects in numbers to cause the withering mentioned, there can be no question, I think, as to the serious nature of their attacks upon the grass. Even when they do not cause withering of grass they must draw seriously upon its vitality.

I have thus far been unable to separate any definite broods. Adults occur during the entire year, and larvæ, which may be quite certainly referred to this species, may be found associated with them during the most of the summer months. Larvæ are perhaps most common during June and in August and September, but whether there are two broods or three, or an indefinite number depending only on the length of the season, I can not now say. It seems most probable, however, that breeding goes on irregularly all through the summer months, but that the adults of spring are represented by only two or three generations of progeny, and the members of the latest broods survive the winter to begin the production of new generations in the spring.

In connection with his description of the species, which was published in 1831, Say makes the remark that "When in the larva state this species is said to depredate on the roots of wheat. Several specimens were sent me by Professor Green in the year 1822, who received them from a farmer in Virginia."

Considering the wide distribution and great abundance of this species, it seems strange that it should have been so little studied or so rarely mentioned in works on injurious insects.

The insect is somewhat less than a fourth of an inch long and appears grayish or yellowish gray, and about the most constant marking are two dots on the front of the head, two on prothorax, and two on scutellum. A form lighter than the typical examples but which seems to me only a light variety, has even these dots obscure or wanting.

The larvæ are light yellowish but seem to be subject to about as much variation as the adults. An extreme form of larvæ, probably belonging to this species, has dark margins to the prothorax and abdomen.

Several other species of *Jassidae* have been observed in grass, but as they are not as yet determined I omit further mention of them at this time.

THE GRASS-ROOT PLANT-LOUSE ALIAS THE DOGWOOD PLANT-LOUSE.

(*Schizoneura corni* Fab.)

Probably the most interesting result of my season's observations from a scientific stand-point, and it may be the most important economically, is the determination of the identity of a form of plant-louse in-

festing the roots of grasses during the summer with one occurring on the leaves of dogwood during autumn. The full import of this connection from the economic stand-point can not be known till it is determined how many species of grasses are affected by the root form and to what extent the migration to dogwood exposes it to attack. If its occurrence is confined to the annual grasses (and it seems to occur only on these), its importance to the farmer will be much less than if it is found to work also on perennial species.

A brief statement of the connection between these two forms was published in *INSECT LIFE* (Vol. II, pp. 108-9), but a fuller account, with details of observations, is proper at this time.

My attention was first called to this species on September 15, when I noticed the air was filled with small insects, which on capture were found to be plant-lice of the genus *Schizoneura*. Their immense numbers, filling the air as far as could be seen in all directions, naturally excited my interest, and I walked some distance in the direction from which they seemed mainly to come (which was with the wind), but without locating their origin, except to observe that they were resting on all sorts of plants and were very plentiful along roads and paths where fox-tail and other grasses were plenty. Upon examination I determined the specimens gathered to be *Schizoneura corni* Fab., specimens of which I had gathered a year or two ago from dogwood. It seemed difficult, however, to account for such an immense swarm of them when dogwood is not especially abundant in the immediate vicinity and had not been observed as infested with aphids. In looking over descriptions of allied species I was struck by the close agreement with descriptions of *Schizoneura panicola* Thos., and, following this lead, I examined the roots of *Setaria* and *Panicum* on September 16, when the winged forms were again numerous in the air. My search was almost immediately rewarded with the finding of numerous wingless *Schizoneura*, and among them some which showed wing-pads and two with wings partly expanded. These were compared carefully with winged *corni* found flying and also with *corni* from dogwood, and showed such close agreement that I felt it important to follow the matter up. One of the specimens, with wings partly developed, was mounted in balsam for future reference; the others, on grass roots, were put in breeding jars. Their subsequent history will be stated later on.

Examinations in the field on the 18th showed lice still somewhat plenty on grass roots, though the *Setaria* examined failed to show them in very great abundance. Examinations the same day, of the dogwood in the timber near, showed on the very first bush noticed numbers of the winged (*pseudogyne*) individuals, and with them numbers of small larvæ evidently just extruded. The colonies accompanying each *pseudogyne* contained from one to a number of larvæ, but none of these could have been more than a day or two old, all very small, scarcely larger than when first born. In no case could I find a leaf on any of

the bushes examined which contained any colonies without the winged mother or where there was the slightest evidence of the previous presence of aphides; no cast skins from old colonies or damaged leaves, and every indication went to prove that the winged form had just settled upon the trees and begun the formation of colonies. While perhaps of little value as proof, it may also be mentioned that no *Schizoneura* had been observed on *Cornus* this fall prior to this date or before the swarming of September 15. A number of branches containing colonies were brought in and kept in water for the purpose of following their development. This was fortunate, as the colonies on the plants out of doors were almost all depopulated a few days later by predaceous insects, so much so that the colonies on plants near at hand and on which I depended for following the species out of doors utterly failed to furnish material for that purpose. Indoors the insects developed rapidly and were followed as closely as circumstances would permit. Molting in these occurred by the 19th, and apparently only one molt occurred before maturity. Only one brood was developed, these becoming sexually mature September 25. Both males and females were apterous and copulation took place upon the leaves and also upon the twigs, the females often traveling down the twigs and branches while copulation was in progress. In every case the females seemed to travel down the branches as far as possible before depositing eggs, and great numbers of them dropped into the water in which the branches were kept. In the woods I have been unable to find any eggs whatever under buds on twigs, and so far as the indoor observations go they differ from those recorded by Mr. Weed. Whether this be due to dryness, the insects seeking a place of some degree of moisture, can be determined by comparisons under varying conditions.

Two weeks after the swarming of winged lice in the air there was another swarming, though the lice were not so numerous as at the first time. This swarming also followed a rain with subsequent cold. As in the preceding case, examination of *Cornus* in the woods showed numerous winged individuals starting colonies, though at this time in some places it was possible to find the cast skins of previous colonies, all of which, however, so far as I could find, had been destroyed by predaceous insects or other causes. My search for eggs in the woods has been futile, and it would seem that nearly all the colonies were destroyed before the maturity of the sexual individuals. I have found, however, oval bodies a trifle larger than the eggs, but resembling them at first sight, though flattened, but which prove to be a small species of *Lecanium*, apparently undescribed.

The lice occurring on the roots of grass, and which were placed in breeding jar the 16th, were mostly unaltered on the 19th, but in the jar I found a fully winged specimen, agreeing exactly, so far as could be seen with hand lens, in the living individual, with specimens flying and also with those on *Cornus*. It was transferred to a leaf of *Cornus* on

twig inserted in water, isolated from other leaves, and which had been carefully examined with lens to see that it was free from larvæ, and protected by cheese-cloth cover. This individual took kindly to the situation, remained constantly on the leaf, and produced a number of larvæ which developed as rapidly as those brought from the woods, agreeing perfectly with them in every particular that I could observe, and proving their ability to develop on *Cornus*. Unfortunately their propensity for traveling down the twigs resulted in their being drowned in the water in which the twig was kept. I think, however, that their developing perfectly on the *Cornus* leaf, and the perfect agreement of apterous males and females so developed with those occurring normally on *Cornus* in woods, is good evidence of identity.

In the meantime lice had been found in some numbers on the roots of grasses not yet dead, especially on *Panicum*, and many of these had been placed in breeding-jars in hopes of securing additional winged specimens. While apparently thriving they failed to acquire wings, but on September 24 I observed in one of the jars an apterous individual, and directly behind it an egg evidently fresh-laid, elongate, oval, greenish, polished, like eggs of *corni* on *Cornus*. This was mounted with the apterous individual, and in the body of the latter another egg was apparent. The egg was laid at the surface of the earth in the jar, and similar eggs were found in pill-boxes in which root-lice were confined. A close examination of roots, especially those of *Panicum* from the field, enabled me to find a number of small apterous individuals like the males on *Cornus* leaves, as well as the small apterous and oviparous females. These occurred with a larger form, exactly like those which had been observed to acquire wings, and the conclusion seemed inevitable that these viviparous and apterous forms produced in the ground a brood of apterous males and females. These latter were observed attempting coition, though in no case did I see the act completed. The males are of an orange color, darker than the females, and differ from males on *Cornus* leaves in being shorter, and in lacking the purplish tint usually present in those. The females agree well with females on *Cornus* leaves, but are shorter, have *six-jointed* antennæ, and are slightly lighter colored, which would be expected in individuals living under-ground. September 28, eggs from these root-forms were more numerous, and by October 3 I found them quite plenty in my jars. One oviparous female was observed with three eggs extruded from the body, adhering by the ends, and the last one still partly within the body. They are whitish at first, but turn yellow on exposure, and later turn quite dark.

The eggs seem to be deposited at hap-hazard on surface of earth, sides of boxes or jars, and each female appears to produce but two or three eggs.

These observations, I am free to confess, appear to complicate the round of life of the species, and to make the complete circle from grass

to dogwood and back less clearly defined, but such a dimorphism, if we may call it so, is not without parallel, and does not seem unreasonable. There seems reason to believe that while a large proportion of the *pseudogynes* acquire wings of perfect development, and migrate to dogwood, that there is also another portion in which the wings for some reason fail to develop, and these from necessity remain on the roots or at best remain near the surface of the ground, and the sexual generation produced by them at the same time as from the winged ones, or perhaps a little later develop by feeding upon grass roots, and deposit their eggs where they have themselves developed. As to whether these eggs are as successful in their further development as the ones deposited on *Cornus* remains for further observations to determine. Possibly in certain seasons they may survive better, and thus provide a double means for the preservation of the species. As to the conditions which might affect the acquisition of wings we can do little more than speculate, but it seems proper to call attention to the possible elements that may furnish a solution.

The day before the first swarming of *Schizoneura* (14th) had been very warm in the middle of the day, with a heavy shower in the latter part of the afternoon, followed by a steady rain in the fore part of the night, and this by a sharp fall in temperature, so that the morning of the 15th was clear and cold (possibly a slight frost). The day remained cold, but was bright and sunny, and the swarming observed occurred in the latter part of the afternoon. Some other aphids were observed on the wing, but very few as compared with the swarms of *corni*. *S. corni* was seen in the air on subsequent days, but comparatively scarce till, again two weeks later (29th), after a very similar condition of weather (warm, with rain, followed by cold), when another swarming occurred. Now, it may be that those individuals, which are at a certain stage when such conditions occur, are enabled to acquire wings while those less fully developed remain without the full expansion of these appendages.

In comparing the two forms infesting grass roots and dogwood, respectively, I have studied great numbers of wingless individuals, winged forms and apterous males and females, and have come to the conclusion that they must all belong to the same species. It will, however, be in place, I think, to place in position for comparison the different descriptions which have been given of the species to show that, notwithstanding the terms used by different authors, and their wide separation in time and place, there is no real discrepancy in them. The original description by Fabricius is very short and general, and is as follows (Ent. Syst., IV, p. 214, No. 19):

Corni. A. *Corni sanguineæ*.

Habitat in *Corni sanguineæ foliis*.

Corpus nigrum abdomine basi et subtus virescente. Pedes nigri. Anus absque stylo et corniculis.

Juniores pallidi macula magna, dorsali, nigra.

Passerini, in Gli Afidi (1860), describes the root form as follows :

Schizoneura venusta, m.

Femina vivipara aptera ovata-convexa, pallide viridis, vel interdum rubella; capite, fasciis dorsalibus anticis tribus, macula discoidali quadrata, fasciis posticis duabus, punctisque marginalibus nigris. Rostrum crura media attingens. Long., 1'''.

Femina vivipara alata capite et thorace nigris. Abdomen viridi luteolum vel rubellum, vittis transversis anticis duabus, macula discoidali subrotunda, fasciis duabus posticis, punctisque marginalibus nigris. Nectaria tuberculiformia nigra. Alae hyalinae, venis stigmatum nigris. Long., $\frac{3}{4}$ '''', 1'''.

Nympha lutea, capite et thorace pulverulentis.

Turmatim in radicibus *Setariae viridis*, *S. glaucae*, *S. italicae*, *Panicis glabri*, *Eragrostidis megastachyae* et *Ceratocloe australis*. Autumno.

Valde similis *Schizoneurae corni*, quae autem diversa dorso omnino nigro in apteris, et abdominis basi et apice tantum albido in alatis.

Thomas gives a translation in his work on Aphidae, which reads:

Schizoneura venusta Pass.

Wingless female.—Ovate convex, pale green, and sometimes reddish; head, three anterior dorsal fasciae, a quadrate discoidal spot, two posterior fasciae and marginal points, black. Rostrum extending about to the middle legs. Length (of body), 1^{mm}.

Winged female.—Head and thorax black. Abdomen, greenish-red or yellowish; two anterior fasciae, a subrotund discoidal spot and marginal points, black. Nectaries tuberculiform and black. Length, $\frac{3}{4}$ to 1^{mm}.

Pupa, yellowish, head and thorax pulverulent. Found on roots of *Setaria viridis*, *S. glauca*, *S. italica*, *Panicum glabrum*, *Eragrostis megastachya* and *Ceratocloa australis* in autumn.

This translation is incomplete and imperfect, especially in the dimensions, which are given as millimeters instead of lines (twelfths of an inch), which would lead one to suppose them about half the actual size. So far as I can see, Passerini's original description is entirely applicable to the specimens obtained from roots of grasses here as well as to fresh specimens of *corni* on *Cornus* leaves.

Walsh published the following descriptions (in 1862) in the Proceedings of the Entomological Society of Philadelphia, Vol. I, p. 304.

Eriosoma? fungicola n. sp.

From recent specimens. Body black, with a plumb-like bloom; basal half of abdomen and whole of venter yellow. Antennae and legs black. Wings hyaline with a dusky tinge; veins dusky, black on the basal half of the costa; third discoidal hyaline nearly to its fork, stigma palish brown. Numerous individuals unaccompanied by larvae, occurred on a large moist fungus a hundred yards from the nearest trees, which were all oaks. Beat solitary individuals unaccompanied by larvae or woolly matter, on two separate occasions from oaks, which, when dried, differ only from the dried specimen of those found on fungus by the metathorax being varied with pale greenish, as well as the base of the abdomen. Length to tip of wings .12 to .13 inch.

The antennae do not quite attain the base of the first discoidal when the wings are expanded, and the stigma is rather more than twice as long as wide. Six specimens in all. *E. querci* Fitch is larger (.16 inch) and is entirely black. Differs also from the other described United States species.

Eriosoma? cornicola, n. sp.

Differs from the preceding only in the body being entirely black. Numerous individuals, unaccompanied by any flocculent matter, and so far as I recollect by larvae, occurred in September on the lower side of the leaves of the Red osier dogwood. Ten specimens.

Dr. Thomas, in repeating these descriptions in the "Aphididae" (8th Report State Entomologist of Illinois, pp. 141, 142), separates the two by *Schizoneura carya* Fitch, so that "Differs from preceding only," etc., refers to *carya* and not to *fungicola*. This circumstance is liable to mislead, unless Walsh's original descriptions are at hand for reference, and may account for the uncertainties that have been stated in efforts to determine Walsh's *cornicola* found on *Cornus*.

Considering that *fungicola* was on a fungus, a plant never known to support Aphides, and that the difference noted by Walsh is such as results from greater maturity of specimens that have located on *Cornus*, and further, that *fungicola* agrees perfectly with both descriptions of *corni* and with fresh individuals found on *Cornus* leaves, it seems pretty certain that these two descriptions refer to one and the same species.

Thomas' description of *S. panicola*, published in 1879 (8th Report, State Entom., Illinois, p. 138), is as follows, and is said to have been written from recent alcoholic specimens:

Winged female.—The front wings with the third discoidal veins once forked; third vein obsolete at base; first and second veins arising very near each other; stigma short, rounded behind; fourth vein nearly straight: costal bent outward to the base, leaving a rather wide space between it and the subcostal; antennae short, reaching about to the base of the fore wing; slightly hairy; third joint rather longer than the fourth and fifth united; sixth slightly longer than the fifth, with a very short, indistinct, blunt spur at the tip; beak rather long, reaching nearly to the hind coxae, slightly hairy; eyes present and of the usual size or nearly so.

Wingless female.—(Probably not fully developed.) Very broadly ovate and very convex, being suborbicular; antennae, reaching about to the end of the thorax, rather thick and heavy and not tapering to apical joints, if any difference rather thicker than the middle ones; third joint longest but not quite equal to the fourth and fifth united; fifth rather longer than the fourth, gibbous on one side at the tip; sixth nearly as long as the third; beak, long, reaching fully to the hind coxae: color of the alcoholic specimens, reddish-yellow; eyes minute and black.

Found on the roots of *Panicum glabrum* and other grasses by H. [Th. ?] Pergande at St. Louis, Mo., in November.

The difference in the length of the beak will certainly distinguish this from *Tychea panici*, even supposing the antennae in the latter to be undeveloped.

Mr. O. W. Oestlund, in Synopsis of the Aphididae of Minnesota (Bull. No. 4, Geol. and Nat. Hist. Surv. of Minn.) describes both *corni* and *panicola*, and their identity could not be more strikingly indicated.

S. corni.

Head and thorax black; abdomen reddish-black, with a large patch of velvety black covering all of the dorsum except three and some of the last segments. Antennae reaching to the end of thorax; not annulated, hairy, with a single row of circular sensoria on the under side, about six to the third joint, three to the fourth, two to the fifth, and one at the contraction of the sixth; III, 0.30^{mm}; IV, 0.12^{mm}; V, 0.10^{mm}; VI, 0.15^{mm}, with the short anguis. Beak reaching third coxae. Wings hyaline, with slender veins; cubital obsolete at base; stigma broad and short, smoky. Honey tubes a circular opening almost on a level with the abdomen. Expanse of wings, 6-7^{mm}.

S. panicola.

Head and thorax dusky or black; abdomen pale greenish with some black marking above, on the last segment at least. Antennae reaching to the end of the thorax,

hairy, third joint the longest, the following subequal; sensoria rather indistinct, three or four to the third joint, and usually one or two to each of the following. Beak reaching abdomen. Honey tubes as circular openings on level of surface of abdomen, but rather conspicuous from being bordered with a ring of black. Wings hyaline with slender but distinct veins. Fore wings with the cubital obsolete for some distance at base; stigma short and broad; stigmal vein but slightly curved near the base, straight. Expanse of wings, about 5^{mm}.

Careful descriptions of the different forms on *Cornus* are given by Mr. Clarence M. Weed (Psyche, V, p. 129), the species being referred doubtfully to *cornicola* Walsh.

Winged viviparous female (pseudogyna pupifera).—Expanse of wings, 6^{mm}; length of body, 2^{mm}; width of body, .80^{mm}; length of antennæ, .90^{mm}.

Black above, except anterior and lateral margins of abdomen, and in many specimens more or less of posterior portion. Beneath black, except prothorax and abdomen (save a black patch in front of anus), which are dull whitish-brown. Rostrum black, except a more or less distinct lighter patch near base, hairy, reaching posterior coxæ. Legs robust, black, except a short brownish space at base of anterior femora; thickly provided with brown hairs. Antennæ robust, beset with brown hairs. Joints I and II, short, smooth; III, long, with row of tubercles on its outer ventro-lateral surface; IV and V subequal, with tubercles as on III; VI, a little longer than V, excavated on its outer lateral surface about two-thirds distance from base. Wing veins mostly brown. Stigma brownish, with interior portion darker.

Described from many specimens taken October 24, 1887, on leaves of *Cornus sanguinea* and *C. sericea*, where for some time previous they had been very numerous, founding sexed colonies. Usually occurring on the under surface.

Apterous male.—Width of body, 0.50^{mm}; length of body, 0.89^{mm}; length of antennæ, 0.47^{mm}.

Body and members brownish or brownish-black, with numerous brown hairs. Eyes black. Body flattened, long and narrow, with nearly parallel sides. Antennæ half as long as body. Joint I, short, swollen; II, small; III, longest; IV and V, subequal; the latter excavated on its apical lateral surface. Legs long, robust, same color as body. Rostrum robust, reaching anterior margin of posterior coxæ.

Described from several living specimens (part taken in *copula*) from *Cornus sericea*, collected October 24, 1887.

Oviparous female.—Width of body, 0.50^{mm}; length of body, 1.14^{mm}; length of antennæ, 0.35^{mm}.

Green, or greenish-brown, slightly darker anteriorly. Shape, elongate oval; sparsely clothed with brown hairs. Eyes blackish. Antennæ green, slightly darker apically; joint III longest, V slightly swollen in middle. Rostrum robust, green, darker at tip, reaching anterior margin of posterior coxæ. Legs unicolorous with body, dusky apically.

Egg.—Elongate oval, 0.56^{mm} long, 0.20^{mm} wide.

Green at first, becoming black by exposure. Deposited on bark, in and about the axils of buds and small branches.

Described from many specimens on *Cornus sericea*, October 24, 1887.

These descriptions are so full that I deem it unnecessary to draw up another. I may mention, however, that the apterous males usually have what I should call a purplish tint with the brownish color when alive, due, perhaps, entirely to the delicate bloom covering them.

The most distinctive character of *corni* is perhaps the hairy antennæ and the six or seven circular sensoria on underside of the third antennal joint. The number of these sensoria varies slightly, but in the form I

reared from grass roots and allowed to colonize on *Cornus* leaf there are the full number common to *corni* and show distinctly. Mr. Oestlund's statement that they are indistinct and but three or four in number might, I think, apply to an extreme variation or to specimens fresh from the ground. The dark spot on the dorsum of the abdomen is not only variable in size but differs much in appearance with the age of the specimen and in dead or preserved specimens. While I am free to admit some puzzling questions, I am strongly convinced of the main point here claimed. There is certainly much more of interest to be learned regarding the species. I feel that only a beginning has been made, and shall watch eagerly for further developments. As the *Aphides* are so uncertain in their appearances and can not be depended upon to furnish material in abundance in every locality, it will add to the certainty of completing the history of this species if entomologists in various localities will make such observations as possible the coming season.

If my conclusions are correct the synonymy for this species will read as follows:

- (1794) *Aphis corni* Fabricius, Ent. Syst., IV, 214.
- (1860) *Schizoneura venusta* Passerini, Gli Afidi, p. 38.
- (1862) *Eriosoma? fungicola* Walsh, Proc. Ent. Soc. Phila., I, 304.
- (1862) *Eriosoma? cornicola* Walsh, Proc. Ent. Soc. Phila., I, 304.
- (1879) *Schizoneura panicola* Thos., 8th Rep. Ill. Ent., p. 138.

SUMMARY.

Schizoneura abundant on grass roots and assuming winged form in latter part of September (15-28) and on several days during this time the air was filled with like insects, and immediately following these flights apparently identical *Aphides* were colonizing on leaves of dogwood, which had hitherto been free from them.

Schizoneura (winged *pseudogyne*) reared from grass roots and transferred to leaves of *Cornus* established colonies apparently identical with those occurring normally on *Cornus*.

Schizoneura (apterous individuals) in some number remain on grass roots and are associated with apterous males and females, the females of which are oviparous.

Individuals of these different forms agree with each other and with descriptions of both *corni* and *panicola* and differences do not exceed the range of variation common to species of *Aphididae*.

CONCLUSION.

Taking all these facts into consideration, I believe that the species of *Schizoneura* infesting grass roots and dogwood leaves and described as distinct species are identical.

That the winged generation of asexual individuals produced from grass roots in autumn migrate to leaves of dogwood of different species and establish colonies of apterous individuals, which become sexually mature and the females of which deposit eggs on dogwood.

That the number of broods produced on *Cornus* in spring (which must now be inferred) and the time of return migration to grass are yet to be determined.

That in addition to the migratory winged autumn brood there appears to exist under certain conditions an apterous form which produces a brood of sexual individuals on grass roots the females of which deposit eggs the fate of which is unknown.

HETEROPTERA INFESTING GRASS.

THE CHINCH BUG.

(*Blissus leucopterus* Say.)

The Chinch Bug is too well known as a grass and grain pest to need any special mention in this connection. It may be noted, however, that it prefers the annual grasses rather than perennials, and were it confined to the noxious Foxtails (*Setaria*) we might have no reason to complain, but its fondness for Hungarian grass is too conspicuous to pass over. It does not appear to multiply as rapidly in sod land, though I have found it in Blue-grass where this alone could furnish it food.

THE LONG BUG.

(*Ischnodemus folicus* Say.)

Were it not for its elongated form this species could be most easily mistaken for the Chinch Bug, for, excepting this peculiarity, it comes nearer in appearance to the Chinch Bug than any of the numerous species which have been confused with that noted pest.

Hitherto I believe it has not been classed among insects of economic importance. It is, however, quite evidently increasing in numbers in this region and should, I think, be mentioned, at least, in this connection. That it is a grass-feeding insect is evidenced by its abundance in all stages in grass land where other plants are scarce or wanting, and would be expected of an insect so closely related to the Chinch Bug. I have found it more common in rather low ground, and especially in the wild grasses between upland and bottom-land, or along the borders of sloughs or small streams.

While only a fall brood of larvæ, developing in July and August and maturing in September, have as yet been observed, it is probable that, as with the Chinch-Bug, there are two broods each year, adults of the second hibernating and depositing eggs in the spring.

If multiplying, so as to become a serious pest, I know of no remedies to suggest further than those applicable to Chinch Bugs, and probably the most efficient one would be that of burning dead grass and rubbish in the fall.

There are several other species of the Heteropterous Hemiptera, notably certain *Capsidæ* such as *Miris affinis* and related species, and several species of *Lygus*, which I suspect will be added to our list of grass pests, but I have as yet made no careful study of their habits.

REPORT OF OBSERVATIONS UPON INSECTS AFFECTING GRAINS.

By F. M. WEBSTER, *Special Agent.*

LETTER OF SUBMITTAL.

LA FAYETTE, IND., *December 14, 1889.*

SIR: I herewith transmit my annual report of observations on insects affecting cereal grains, made under your direction, during the current year. A more elaborate report, treating of the destructive grain insects of the United States, to be prepared jointly with yourself, is nearing completion, and the present report is submitted now, in order to avoid the necessity of including details in the more important work to follow. As usual, I am under many obligations for the determination of specimens and numberless other courtesies.

Respectfully submitted.

F. M. WEBSTER.

Prof. C. V. RILEY,
U. S. Entomologist.

THE WHEAT STRAW WORM.

(*Isosoma tritici* Riley.)

These insects have not been observed by me in any great numbers since they were last treated in my reports, and the species is only mentioned in order to record the occurrence of a female of the wingless spring form, on the 18th of July, in a field of wheat.

THE WHEAT STEM MAGGOT.

(*Meromyza americana* Fitch.)

Since the establishment of the fact of a summer brood originating during the month of August, and largely, it is supposed, in volunteer wheat, considerable emphasis has been placed upon the destruction of this illegitimate growth of grain. There has, however, been pretty good cause for believing that the insect developed also in other plants, and this season we have reared the adult from Blue grass, *Poa pratensis*, during the latter part of August.

Since the discovery of the species there has been nothing placed on record relative to its discrimination between varieties of wheat, or

whether these insects really possessed any such instincts, the inference having been that one variety was as acceptable to them as another. Bearing upon this point I have obtained some interesting information, which, though by far too slender a thread on which to hang a positive assertion, yet forms sufficient grounds for a suspicion that the species may possess some exceedingly fine instincts regarding plant tissue.

In the month of September, 1888, a field of oat stubble on the experiment farm was subdivided, two plats each several acres in extent being sown, the one to velvet chaff and the other to Michigan Amber wheat. Between the two was a narrow strip comprising a mixture of both varieties. From the beginning of preparation of the ground to the end of harvest this year all conditions excepting seed were exactly the same.

The attacks of these larvæ were quite severe during June, and on the 14th of this month an examination of the plats above mentioned developed the fact that in the velvet chaff the destroyed heads outnumbered those in the Michigan Amber in the proportion of about four to one. Furthermore, the narrow strip of mixed grain intervening showed very much the same feature. I confess that I am unable to detect any reason for this difference in the severity of the attack other than in the nature of the straw; that of the velvet chaff being under ordinary conditions a few days earlier in maturing, yet it is known among farmers as possessing a softer straw than the Michigan Amber, which fact presupposes the tissue of the stem immediately above the upper joint to be to a corresponding degree more tender and juicy at the time of oviposition by the females.

THE WESTERN STRIPED CUTWORM.

(*Agrotis herilis* Grote.)

The present year has been conspicuous for the severity of cutworm attacks, especially in corn-fields, the most abundant and pernicious species thus engaged being the one under consideration. Ordinarily we look for these dusky, semi-subterranean destroyers in fields of recently broken grass lands, but this season their ravages were not to be limited by any such proscribed bounds, and old lands suffered with the new.

On the 28th of May I visited a field of corn a few miles out of the city of La Fayette, which had been nearly ruined by cutworms, notwithstanding the present was the seventh consecutive crop of corn which had been planted on this ground. In fact, so abundant were the pests, that from a mass of dried weeds and earth, covering a couple of square feet, and which had been left by the plows, I took 36 individuals, and a clod a few inches away concealed 5 more; the whole number evidently belonging to the same species.

The only apparent cause for this congregating in corn-fields, and in this one in particular, is that during the ovipositing season last sum-

mer the grass lands in this section were withering and drying up under a terrible drought. This corn-field had been poorly cultivated and the lower portions grew up to grass and weeds, thereby forming a more desirable locality for the females to lay their eggs. In other words, the drought of August and September of 1888 drove the moths to the corn-fields to oviposit, and the abundance of worms this year is the result.

The thirty-six cutworms collected on May 28 were taken home and immediately placed in a breeding cage, being fed upon clover during the few days they remained above ground. The first moth appeared on August 23, followed by others up to the 26th, when a medium-sized *Anthrax* was also observed in the cage. As nothing could be found in the literature at hand to indicate that any of the *Bombyliidae* had ever been reared from lepidopterous larvæ, in this country, its occurrence was supposed to be accidental, the larva having been in some way taken up with the earth in the cage. It was followed, however, on September 1 by a second adult, and two more appeared on the 4th, others appearing up to the 9th, when all doubts as to the host of these flies were removed by two adults issuing from a couple of chrysalids laying on the surface of the soil, the *Anthrax* leaving their empty pupa cases protruding half way out from the chrysalids of the *Agrotis*. The flies may be roughly described as from 10 to 13^{mm} in length, black, densely covered with fine silky hairs, those on præscutum and episternum of mesothorax, basal half of abdomen, and tuft on posterior margin of penultimate segment being silvery white, changing to yellowish, especially on the shoulders.

The same species was frequently observed, near the middle of September, hovering about over the surface of the ground under trees recently denuded of their foliage by the larvæ of *Datana ministra*, thereby conveying the impression that they might be parasitic upon that species also.

As nothing whatever is known of the time and method of oviposition of the *Bombyliidae*, it will only be safe to say that the eggs were deposited either on or about the bodies of these cutworms prior to the 28th of May.

In a most excellent paper by Dr. Riley, in the Second Report U. S. Entomological Commission, pp. 262-269, larvæ of an allied species is mentioned as infesting the egg-pods of *Caloptenus spretus*, being found of different sizes during most of the year. From rearing this species, *Systoechus oreas*, O. S., Dr. Riley concludes that, "as a rule, but one year is required for full development;" but there is great irregularity and a tendency to retardation of such development.

Should the species under consideration be of similar habits, the eggs would, as a matter of necessity, have been deposited last fall, the larvæ wintering over in the bodies of these cutworms, which are not usually over half grown at the beginning of winter. If this be true it is certainly an interesting feature of parasitism.

THE ARMY WORM.

(Leucania unipuncta Haw.)

With the rapidly increasing area of low, wet lands, which are being under-drained and brought into cultivation, the natural haunts of this species becomes more and more encroached upon. What the ultimate effect of this change of natural conditions will amount to in the future, and whether or not it will have a tendency to scatter the spring brood of moths in their selection of places of oviposition, only future years will answer. In accordance with the characteristic partiality of the species for low, damp localities, the outbreaks in Indiana this year have been restricted to the lower laying and flatter portions of the State, where a very considerable part of the land remains undrained, except by open ditches. While this state of affairs has been going on, the fact that dry seasons are favorable to the increase of the species has been amply demonstrated. The last two summers have been unusually dry, and the spring of the present year, up to May 30, was exceedingly dry, making three consecutive years of drought, during all of which this pest has appeared in various portions of the State, the maximum injury being caused the present summer. During this period, also, we have had wet springs and dry summers and dry springs and wet summers, proving conclusively that wet weather has little if any direct influence upon the increase or decrease of numbers. In short, it is difficult to resist the suspicion that this ebb and flow, so to speak, may be due more to the fluctuation of natural enemies than to the direct influence of meteorological conditions, severe droughts excepted.

In the vicinity of Princeton, Ind., where considerable damage was done last year, there occurred this season only one weak, aborted outbreak, in a small field of rank growing timothy grass. A slight attack three years ago on the borders of a large tract of swampy land in the vicinity of La Porte, Ind., was not followed by others, either last season or this, although this year similar and more serious outbreaks occurred in that immediate section of the State, and within a few miles of the same locality. Such phenomena can not be wholly attributed to meteorological conditions, most certainly. The most efficient parasites of the army-worm are two species of *Tachinae*, and we have reared both plentifully this season. The local effects of these parasites is probably more lasting than we are given to suppose. A circumstance came under our observation recently where the attack of a similar species of *Tachina* on the larvæ of *Datana ministra*, infesting an isolated walnut tree, was such that the tree has been free of the caterpillars since 1885. If the effects are equally lasting in the case of the army-worm it will be difficult to foretell their appearance in dangerous localities, even in seasons supposed to be most favorable.

Again, the secret of the power of the army-worm to destroy is in their massing together in endless numbers. Were it not for this they would

not be more destructive than others of the group of cut-worms to which they belong. As stated in the beginning, the prevailing system of underdrainage has at present a tendency to emphasize this gregarious habit by restricting the area of wet grounds.

Whether this will continue to be the case, or whether, after a time, the effect will be to break up the habit of massing into large swarms, and diffuse them into smaller and less destructive colonies, remains yet to be seen.

The heaviest damage has this season, here in Indiana, fallen upon the rye crop, a state of affairs which has excited much comment among farmers. The reasons for this seemingly general selection of this crop, for depredation by the worms, are (1) on account of its hardy nature, rye is often sown on these swampy or mucky lands, as it withstands the weather there better than any other crop; and (2) by nature it is a rank grower, and, therefore, a field in spring presents to the female moth all the requirements of a suitable locality to place her eggs, viz, where her progeny will have an abundant supply of succulent food, in a damp place and shaded from the direct rays of the sun. In all fields of rye examined which have been ravaged by the army-worm, the latter were found to have originated in the fields themselves and had not migrated to them. Cases were not uncommon, however, where the worms originated in grass lands and from thence invaded fields of wheat and oats.

The prospect of controlling the outbreaks of the army-worm in the future seems encouraging, provided the farmer is perfectly familiar with their habits. Much of the damage done might be prevented if decided measures were taken at the start. The trouble is that too often the farmer wastes the most precious time in waiting to see what the worms are going to do, and by the time he finds out they are beyond control.

So far as I have been able to learn, where a neighborhood has turned out *en masse*, and taken decisive measures to destroy the worms, little injury has been done. These measures have consisted in ditching around the infested area and either flooding the ditch with water, or otherwise destroying what fell into it, and driving stock over the area inclosed by the ditches, whereby vast numbers of worms were crushed. From pupæ obtained in Fulton County the following parasites were reared: *Ichneumon brevicauctor* Say, *Nemorana leucanie* and *Drymeia* sp? *Ophion purgatus* Say, also a parasite on *Leucania*, was this year reared from pupa of *Scoliopteryx libatrix*.

THE FALL ARMY-WORM.

(*Laphygma frugiperda* Ab. and Sm.)

In 1885 and again 1889, we found larvæ of this species feeding on the tassels and unfolding leaves of young volunteer corn, late in September, in the vicinity of La Fayette, Ind. In both cases we reared adult

moths from the larvæ, the former appearing during late October. These breedings would seem to indicate that at least some of the fall brood may winter over in the adult stage.

A NEW CUT-WORM.

(*Luperina (Hadena) stipata* Morr.)

On May 28, while searching for *Sphenophorus* in a field of corn planted on recently broken prairie sod, a depredator was found which both in itself and method of work was new to me. Though the young corn was at the time several inches high, many of the plants were withering and dying, but aside from this neither the plant itself nor the earth about it gave the least indication of the presence or nature of the destroyer. Digging down in the earth about the hills, one or more of the shoots would be found wholly or partly eaten off, either near or a short distance above the seed, and in a single instance the seed kernel itself was observed being eaten. The method of attack appeared to be to first eat into the tender stem and then to burrow upward, after the manner of *Gortyna nitela*, above ground, and as soon as one plant was consumed another was attacked, without the worm coming to the surface. The larvæ were rather slender, from half to three-fourths of an inch long, quite active and in general coloration somewhat resembling the larvæ of *Crambus zellus*, but being more robust, spinning no web and living wholly under ground. Larvæ taken from the field June 8, continued feeding in confinement until early in July, and the moths appeared in the breeding cage about the 25th of the same month. On account of being absent from home much of the time between the middle of June and 20th of July, it was impossible for me to get exact dates.

My own collections of larvæ were from recently broken prairie sod only, none being found in timothy or blue-grass sod adjoining. Farmers in the vicinity of this field state, however, that the worm does work in timothy sod, and serious damage in a fall-plowed field was attributed to their work.

Under date of June 15, Mr. J. C. Besom, of Anderson, Madison County, Ind., wrote me that a kind of Cut-worm had appeared in his fields which he had never observed before. They began working on clover sod, about May 10, and destroyed the first planting of corn, and were at the date of writing making way with the second planting, working underground and eating the plants from the roots upward to the surface of the ground.

The larvæ are whitish, striped on the back with brown, head and cervical shield yellowish. Their general form is more slender and longer than that of ordinary cut-worms, being nearer that of *Gortyna*.

(*Crambus zeellus* et al.)

While natural enemies of the larvae of various species of *Crambus* have been recorded, those attacking the adult moths are, so far as published record goes, rather limited in point of numbers.

One of the probable enemies of our corn destroying *Crambus* is a Neuropter, a *Bittacus* near *stigmaterus*. During August Mr. W. O. Pritz brought me an example which he had observed to attack a female moth, chasing her about, finally worrying her down and killing her. The remains of the moth when brought to me were too much mutilated to determine.

Mr. J. N. Latta, of Haw Patch, Ind., tells me that the moths of *Crambus laquealellus*, which I observed in abundance in his yard, were destroyed in great numbers by the Wood Pewee, *Contopus virens* L.

THE WHITE GRUB.

(*Lachnosterna* spp. ?)

The present season has been marked by the most serious depredations of these pests that has occurred for many years. Pastures, meadows, and corn-fields have suffered in some instances to the extent of 75 per cent. of the crop. Fields this season devoted to corn, but for thirty years previous under cultivation, continuously producing some one of the cereal grains, have been very seriously damaged, large areas of the corn withering and dying in the hill during August and September, from five to twenty grubs being found in and about a single hill. As early as May 13, at the Experiment Station, they were destroying young barley growing on a plot of ground which had produced a crop of this grain for the six preceding years. Adjoining this plot of barley was another which had been devoted to oats during the same period, but which was only slightly attacked. A precisely similar plot of buckwheat, which had produced the same crop for the same period, was found also invaded, and on July 24 the grubs were found in the act of cutting off the plants, now several inches in height.

A number of experiments were made with various substances with a view of determining the possibility of destroying the grubs without injury to the plant infested. Corn was the plant used in these experiments, being at the time the most convenient to obtain; the substances used, however, had they been ever so effective, could hardly be applied with practical advantage by the extensive farmer.

Experiment No. 1.—Placed a grub about the roots of a single plant on May 14; two days later, applied a sufficient amount of air-slaked lime to the surface of the ground to cover very lightly, watering thoroughly.

Result, May 22, plant killed but the grub uninjured.

Experiment No. 2.—Placed grub about roots of plant May 14; two days later applied table salt in solution at rate of 235 pounds per acre.

Result, five days later, plant and grub alike uninjured. A second application killed the plant but not the grub.

Experiment No. 3.—Placed grub about root of plant May 14; two days later applied fresh unleached ashes to surface of ground in sufficient quantity to cover lightly.

Result, five days after, plant and grub alike uninjured.

Experiment No. 4.—Single grub placed about roots of plant May 14; two days later applied 4 ounces gas-tar water.

Result, next day, plant killed; grub uninjured.

Experiment No. 5.—Single grub placed about roots of plant May 14; two days after earth about roots thoroughly saturated with tobacco water.

Result, five days after, plant and grub alike uninjured.

Experiment No. 6.—Single grub placed about roots of plant May 14; two days later applied 1 drachm Diamond soluble bone* in solution.

Result, six days later, plant and grub unaffected by application; grub eating off the roots.

Experiment No. 7.—Grub placed about roots of plant May 14; two days later $\frac{1}{4}$ ounce carbon bisulphide poured in hole made in earth near roots and immediately refilled with earth.

Result, second day after, plant and grub both dead.

Experiment No. 8.—Single grub placed about roots of plant May 14; two days after thoroughly saturated the soil with ammonial water of 1.025 specific gravity, 2.68 per cent. ammonia reduced 75 per cent.

Result, three days after, plant killed but the grub was alive and active.

*Experiment No. 9.**—One grub placed about roots of plant May 22 and one drachm of phosphate salt applied in solution to the soil about roots. On 23d, corn was being destroyed by the grub and the next day the plant was wholly eaten off while his grubship appeared uninjured.

Experiment No. 10.†—Single grub placed about roots of plant and one drachm of fertilizing salt applied in solution to soil about roots.

Result, two days later, plant withering, grub all right but had not fed from plant which soon died.

Experiment No. 11.—Grub placed about roots of plant May 22; soil at once saturated with solution of powdered Pyrethrum and water; 1 ounce of powder to gallon of water.

Result, two days later, neither plant nor grub injured.

Experiment No. 12.—Grub placed about roots of plant May 22; next day the soil about the roots was drenched with decoction of Burdock leaves.

* Analysis:

	Per cent.
Available phosphoric acid	13 to 15
Insoluble phosphoric acid	1 to 3
Total	15 to 17
Ammonia	$\frac{1}{2}$ to 1

† The phosphate salt and fertilizing salt used in experiments 9, 10, and 14, were sent to the Indiana experiment station by the manufacturer, E. S. Fitch, Bay City, Mich.

Result, two days later, plant untouched ; grub active, but seemingly unaffected by application.

Experiment No. 13.—October 6, earth in field in the vicinity of wheat plants being destroyed by white grub, thoroughly drenched with decoction of Burdock leaves.

Result of examination on October 14: The grub was found a short distance from the plants uninjured, it having evidently destroyed several after application of liquid.

Experiment No. 14.—October 3, earth about wheat plants, being destroyed in field by white grub, thickly covered with fertilizing salt and drenched with water.

Result of examination October 14 exactly as in the preceding, except that the grub was at a greater distance from plants.

Up to the present time, no Dipterous parasite has been recorded as preying upon white grubs, as the subterranean habits of the pest contributes to its protection in this respect. There is, however, pretty good evidence that there is at least one species of fly which exists to some extent in holding these grubs in check. On September 21, while who advertises both as not only being excellent fertilizers, but also very destructive to insect life, especially chinch-bugs and cut-worms.

The following analyses were kindly made for me by Prof. Henry A. Huston, chemist of Indiana experiment station:

I. *Phosphate salt.*

A. Qualitative analysis.

Bases present:

Calcium,

Sodium,

Iron, trace,

Aluminium, trace,

Magnesium, trace,

Organic matter, trace.

Principal constituents: Common salt, gypsum, carbonate of lime.

Acids present:

Hydrochloric,

Sulphuric,

Carbonic,

Silicic, trace,

Phosphoric, trace.

B. Per cent. phosphoric acid present, .03.

II. *Fertilizing salt.*

A. Qualitative analysis.

Bases present:

Sodium,

Calcium, trace,

Organic matter, trace,

Phosphoric, slight trace.

Chief constituent: Common salt.

Acids present:

Hydrochloric,

Sulphuric, trace,

Silicic, trace.

B. Quantitative analysis.

	Per cent.
Salt (NaCl)	97.70
Gypsum (CaSo)	.41
Insoluble matter	.47
Moisture	1.09
Soluble organic matter and loss	.30
Total	100.00

Samples drawn at experiment station from full sacks, special care being taken to insure fair samples. Neither of these samples contain an appreciable amount of phosphoric acid, potash, or nitrogen,

collecting material for experimentation, in a field seriously damaged by grubs, we found a hill of corn, which, though it contained none of the depredators, bore every evidence of having been destroyed by them, as other hills in a similar condition about it contained from 5 to 10 individuals. Instead, however, a larva of a species of *Erax*, near *bastardi*, was found. As the larvæ of *Erax* are known to be carnivorous, we can only conclude that the one found had made way with the grubs, but not until after the latter had destroyed the corn.

THE VARYING ANOMALA.

(*Anomala varians*, Fabr.).

The only record of this species, as a grain destroying insect occurs in the report of the Commissioner of Agriculture for 1884, p. 412, where Mr. Eugene F. Barns, of Marion, Marion County, Kans., reported the beetle as working serious damage to wheat in the field during the month of June, destroying 1,000 bushels for one farmer.

These beetles occur generally over the State of Indiana, and we have frequently met them hovering on heads of wheat in the field, but never remarked any serious injury. In this State the adult insects are preyed upon by one of the *Asilidae*, *Laphria tergissa* Say, and we have several times caught these flies on wing with one of the beetles in their clutches, their beak puncturing the body of their victim.

THE WHEAT WIRE-WORM.

(*Agriotes mancus*, Say.)

A number of experiments were made with a view of learning the effect of the applications of salt, as against the larvæ of this species.

The method employed was to place a number of kernels of corn in earthen pots, and transport larvæ from the fields, where they were engaged in destroying wheat, placing them among the corn in these pots, the salt being applied in different quantities to the surface of the ground.

Experiment No. 1.—April 26, six kernels of corn, and two wire-worms nearly full grown, were placed together in a pot filled with earth, the latter being saturated with water from beneath. Common barrel salt was then applied to the surface of the soil, at the rate of 940 pounds to the acre. May 1, watered from above.

Result, the pot was examined May 7, and both worms found unaffected, they having in the meantime eaten nearly all of the corn, the uninjured kernels failing to germinate.

Experiment No. 2.—This was made at the same time as No. 1, all conditions being the same, except that salt was applied at the rate of 470 pounds per acre.

Result the same as in experiment No. 1.

Experiment No. 3.—May 7, placed three of the larvæ used in the preceding experiments and one fresh from the field, with corn in pot of earth, saturating the latter from below, and covering surface with salt in the proportion of 24,500 pounds per acre.

Result five days later; the worms were alive and as active as they ever were. Corn slightly eaten, but none showing any indication of growing, while kernels from same ear planted in unsalted soil were sprouted. The corn used in all experiments was from the same ear.

Drasterius elegans Fab.

The larva of this species has been mentioned in my previous reports as destroying other insects, and themselves injuring young corn. In the present instance they were found exceedingly abundant, on November 15, near New Castle, Ind., where they were evidently working serious injury to a field of young wheat, sown in growing corn about September 5. This field had produced three consecutive crops of wheat—then the present crop of corn, among which the young wheat was growing. It was true the wheat was seriously infested by Hessian fly, and therefore the question may arise as to whether the worms were not destroying these; but the damage to the field was by far too great to have been done by the fly alone, and many of the plants had been eaten off below the ground.

With this new revelation regarding their food habits, it seems probable that a part of the wire-worm injuries to wheat sown among corn may be due to this species, instead of the preceding.

THE TWELVE-SPOTTED DIABROTICA.

(*Diabrotica 12-punctata*.)

The adults of this species have been observed in greater abundance than ever before. Gardens and fields have been literally overrun with them. The sexes were observed pairing as early as the 17th of April, thereby promising larvæ sufficiently early to attack young corn, even though planted at the usual time. The list of food plants has this season been observed to include the following, not previously reported: Wheat, cabbage, cauliflower, and beans; an adult was also observed feeding on volunteer oats December 14.

THE SWAMP SPHENOPHORUS.

(*Sphenophorus ochreus* Lec.)

Few insects afford a better illustration of the fact that a comparatively harmless species may, by force of circumstances, suddenly become extremely injurious. Known to the entomologist since 1858, and by no means a rare insect, its habits unstudied because of its secluded haunts and valueless food plant, the species appears to have been overtaken by this progressive decade in agriculture.

The swamp composing the field which formed the basis of the study of this insect was broken up some thirty years ago and two crops of corn raised on it without damage from insect attack, after which, by reason of being too wet, it was allowed to revert back to its original state. Fifteen years ago a second attempt was made to bring it into cultivation, and a single crop of corn raised from a portion of it, this time the insects being noticed, but doing no material injury. The land

was again allowed to go back to its primitive state, and remained thus until last season, when, after being drained, a portion was broken and the remainder brought into cultivation the spring of the present year, with the results here given.

Other fields of swamp land, in the same neighborhood, have suffered in the same manner as this one, but there is at present no information of serious damage until within the last three or four years.

The first published notice of the destructive habits of these insects is found in a brief notice which appeared in several agricultural papers during July, 1888, to the effect that Professor Forbes had found them to be very destructive to corn planted on recently drained swamp lands in Illinois, the adult feeding upon a species of rush (*Scirpus*) and a common reed (*Phragmites*), and when these were destroyed they transferred their attention to the young corn.

On May 23, adult beetles were sent me by Mr. Quincy Earl, a farmer residing near Dayton, Ind., a small village about 8 miles from La Fayette, with the statement that they were destroying his corn.

The beetles were at once confined with corn plants growing in flower pots, the males proceeding to bury their snouts into the tender stems, near the surface of the soil; but the females, to my utter astonishment, burrowed down into the earth, out of sight, and staid there.

Stormy weather prevented my visiting the locality until June 2. The infested field comprised about 75 acres of recently drained swamp land, plowed the present spring, except a small portion which had been devoted to corn the previous year, and the first and second planting destroyed by the beetles. On that portion of the field plowed this spring the young corn was not yet up, but on that portion which had been cultivated last year and planted earlier this year than the newer-plowed portion, the young plants had been totally destroyed, the lack of their natural food having evidently driven the insects to this part of the field, as other fields in the vicinity had not suffered the second year after the ground was first broken, although the first crop had been destroyed. At the time of my visit the beetles were feeding on a species of rush, *Scirpus atrovirens*, Muhl., puncturing the stems just below the surface of the ground and eating out the tender, folded leaves. The sexes were pairing, but I could get no eggs. A large number of adults of both sexes were taken home, as also were specimens of the *Scirpus*, including the roots, which are bulbous and exceedingly hard and compact. These plants were placed in flower pots, and on each was placed a single pair



FIG. 1.—*Sphenophorus ochreus*: a, larva; b, adult—enlarged (after Riley.)

of adults. The next day the males were engaged either in pairing or feeding upon the *Scirpus*, but the females, when not paired with the males, had burrowed down into the earth, out of sight.

On a second visit to the infested field, June 11, but few females were to be found above ground. The young corn was coming up well, but being rapidly destroyed by the males and a few females, except where *Scirpus* was growing in sufficient abundance to provide an ample supply of food.

Absence from home, from the middle of June until the middle of July, not only interrupted my observations, but a press of other work prevented my visiting the field again until August 21, both plants and beetles in pots having in the mean time died.

As a result of this last visit I found two adults, one of which was feeding on a small dwarfed stalk of corn and the other on *Scirpus atrovirens*.



FIG. 2.—Work of *Sphenophorus ochreus* in roots of *Scirpus*—natural size (after Riley).

An examination of the root of this reed revealed full-grown larvæ (Fig. 1, *a*) and fully developed adults still within the bulbs. Other bulbous roots of the same plant gave evidence that the adult had only recently quitted its birthplace. Hurrying home, my plants in the flower pots, long ago dead, dried up and, as I thought, worthless, were examined and in nearly every one was found a fully developed adult, none of which had escaped from the bulbous roots wherein they had developed. (Fig. 2.)

Still another visit to this field on August 30 confirmed all previous observations, and a single pupa was also found in a bulb of the *Scirpus*.

From what is known of the habits of other species of this genus, coupled with the fact that fields of corn are not attacked by the beetles after the first year following the breaking of the ground, it seems highly improbable that there should be more than one annual brood. This being the case, its life history will likely be as follows: The insect hibernates in the adult stage, coming forth from its hiding places in spring, the females depositing their eggs during May and June in the roots of *Scirpus*. The larvæ hatching from these develop to adults and emerge in about three months.

From the vast differences existing between the plant in which the species breeds and that of the corn plant, the great improbability of the insect ever breeding in corn will at once be seen. The whole problem of prevention seems to settle in the destruction of these reeds, root and stem, the season prior to devoting the ground to corn. The eggs are as a rule deposited in bulbs formed the preceding year, and

we have found healthy adults in bulbs after the latter had been thrown out by the plow and lain in the sun for over a month. We have also found them developing in bulbs in ground plowed in May and again in July, indicating that little or nothing can be accomplished by summer fallow.

The most practical and probably the most effective method of destroying the food plant of the pest is to sow rye or some other crop on the land the first season after breaking.

THE CHINCH BUG.

(*Blissus leucopterus* Say.)

The history and distribution of the Chinch Bug in Indiana offers some problems not only very perplexing but exceedingly difficult to solve. In fact, we shall here make no attempt toward a solution, but rather to separate a few of the many complex elements which are thought to influence the distribution and numbers of the pest, and to some extent at least indicate how far they may be considered or perhaps eliminated entirely from any independent relation to the subject, thereby affording aid to the future investigator.

It is well known that although Thomas Say, at the time he described the species, was residing at New Harmony, Indiana, nevertheless his description was drawn from a single specimen taken by himself on the Eastern Shore of Virginia, and so far as we know he may have died ignorant of its occurrence in his own or any of the adjoining States.

Recently, Professor Forbes has collected some data showing that the species was destructively abundant in Edwards County, Illinois, as early as 1828, and was also observed in Richland County in 1823.

Strictly in accordance with the above, while that portion of Illinois lying adjacent to Indiana, separated only by the Wabash River, has suffered again and again through the ravages of the Chinch Bug, crops on the Indiana side have not often suffered from any extensive or widespread ravages of the pest. Not only this, but at the present time the worst infested portion of Indiana is composed of those counties whose western border is the Wabash River, which separates them from Illinois, and from whence the insect occurs in continually diminishing numbers northward and eastward until we reach the northern counties of La Porte, St. Joseph, Elkhart, La Grange and Steuben, where its depredations are almost entirely unknown.* Indeed, during the years when they are the most numerous elsewhere, I have found them in these counties only with difficulty, and few of the farmers know what the insect is like. In almost exactly the same latitude in De Kalb County, Illinois, within 60 miles of Lake Michigan, they have been a serious pest since 1855.

* The only exception known to me was in Elkhart County, where they were reported to Mr. J. R. Dodge, Statistician of the Department of Agriculture in 1857. (See Bull. 17, U. S. Dept. Agri., Div. Ent., p 9.) Mr. Dodge has very kindly looked up this matter, and writes me that these bugs were only reported from one locality in very limited numbers and did no appreciable damage.—F. M. W.

A line drawn from the northwestern corner of Indiana diagonally across the State to the Ohio line, at the southeast corner of Jay County, will divide from the remainder of the State nearly all of twenty-four counties over which the Chinch Bug is either unknown or occurs in too limited numbers to cause serious damage. These are the counties enumerated in Tables A and B. As the numbers of counties from which I have information of serious and wide-spread damage does not amount to twenty-four, I have added others, in which we have observed considerable numbers of Chinch Bugs, and filled out the number with counties situated in the infested district. These are enumerated in Tables C and D.

TABLE A.—*Acreage of various grains produced in 1887 throughout the area over which Chinch Bugs do not occur in destructive numbers.*

Counties.	Wheat.	Oats.	Rye.	Barley.	Total small grain.	Corn.	Excess of small grain over corn.
Adams	26,936	9,142	255	35	36,368	30,257	+ 6,111
Allen	48,362	25,687	2,065	101	76,215	42,004	+34,211
Blackford	12,543	2,544	196	41	15,324	16,000	— 676
De Kalb	30,097	13,390	211	157	43,855	22,135	+21,720
Elkhart	44,896	15,207	705	90	60,898	35,145	+25,753
Fulton	29,903	5,684	390	35	36,012	25,827	+10,185
Grant	42,077	5,455	347	147	48,026	49,225	— 1,199
Huntington	34,888	10,693	800	195	46,576	38,145	+ 8,431
Jay	29,588	8,766	275	145	38,774	39,656	— 882
Kosciusko	42,268	13,274	240	162	55,944	40,065	+15,879
La Grange	36,903	9,818	873	37	47,631	28,292	+19,339
Lake	2,808	26,690	1,284	275	31,057	30,637	+ 420
La Porte	43,904	15,054	802	335	60,095	39,690	+20,405
Marshall	35,062	10,145	1,244	186	47,637	33,238	+14,399
Miami	44,212	7,919	139	168	52,438	42,301	+10,137
Noble	38,797	12,345	120	44	51,306	29,452	+21,854
Porter	15,312	16,365	1,026	236	32,939	21,042	+11,897
Pulaski	19,267	7,828	1,570	394	29,059	23,686	+ 5,373
Starke	3,591	2,916	1,657	298	8,462	7,911	+ 551
Steuben	27,414	9,253	219	310	37,196	22,200	+14,996
St. Joseph	41,525	11,482	440	30	53,477	30,698	+22,779
Wabash	41,109	8,391	115	149	49,764	45,638	+ 4,126
Wells	32,301	6,196	572	54	39,123	39,322	— 199
Whitley	25,633	9,727	95	45	35,500	24,753	+10,747

TABLE B.—*Acreage of various grains produced in 1888 throughout the area over which Chinch Bugs do not occur in destructive numbers.*

Adams	23,130	16,818	249	51	40,248	31,417	+8,831
Allen	50,469	27,228	1,895	172	78,764	43,775	+34,989
Blackford	11,057	3,280	253	140	14,730	16,633	— 1,903
De Kalb	28,145	14,249	138	169	42,701	25,474	+17,227
Elkhart	43,818	14,783	1,013	78	59,692	36,663	+23,029
Fulton	33,976	6,306	267	12	40,561	29,795	+10,766
Grant	38,808	5,593	316	201	44,918	48,581	—3,663
Huntington	32,639	10,990	218	186	44,033	40,218	+3,815
Jay	25,433	9,666	311	160	35,570	40,750	—5,180
Kosciusko	39,878	14,201	334	135	54,548	41,025	+13,523
La Grange	33,540	10,285	750	55	44,630	30,252	+14,378
Lake	3,874	21,026	1,330	221	26,461	29,510	—3,049
La Porte	40,642	18,033	772	787	60,234	41,345	+18,889
Marshall	33,187	11,095	1,449	271	46,012	37,134	+8,878
Miami	44,250	8,160	126	188	52,724	42,743	+9,981
Noble	37,983	14,336	217	44	52,580	29,915	+22,665
Porter	16,618	17,428	1,593	213	35,882	27,863	+8,019
Pulaski	17,007	3,407	1,633	282	29,339	26,232	+3,097
Starke	3,965	3,476	1,696	237	9,374	8,633	+741
Steuben	25,944	10,288	310	317	36,859	21,373	+15,486
St. Joseph	37,602	12,170	642	714	51,128	29,343	+21,785
Wabash	40,202	9,892	183	73	50,350	44,080	+6,270
Wells	28,437	8,352	611	147	37,547	38,009	—462
Whitley	21,789	10,617	65	39	32,540	23,503	+9,037

TABLE C.—*Acreage of various grains produced in 1887 throughout the area over which Chinch Bugs occur sometimes in destructive numbers.*

Counties.	Wheat.	Oats.	Rye.	Barley.	Other small grain.	Corn.	Excess of small grain over corn.
Benton	1,592	35,529	390	125	38,036	71,714	-33,678
Clay*	22,610	9,963	160	211	32,944	26,447	+6,497
Crawford*	7,513	9,389	25	.....	16,927	15,491	+1,436
Daviess	40,186	10,575	340	42	51,143	39,472	+11,671
Dubois*	24,527	10,950	20	87	35,581	22,042	+13,541
Gibson*	72,513	5,740	386	31	78,670	45,108	+33,562
Green	24,943	11,930	239	178	37,290	34,141	+3,149
Jackson	27,584	14,733	297	45	42,659	42,633	+26
Knox*	48,483	6,426	207	68	55,184	47,331	+7,853
Lawrence	11,423	14,395	136	51	26,065	25,228	+777
Martin	15,740	7,766	136	191	23,833	21,493	+2,440
Monroe	9,505	9,399	35	40	18,979	16,462	+2,517
Orange	12,322	17,708	84	96	30,210	26,836	+3,374
Owen	14,343	9,705	91	20	24,159	16,910	+7,249
Parko	33,828	9,426	297	66	43,617	39,751	+3,866
Pike	35,698	9,080	83	107	44,968	30,095	+14,873
Posey*	60,902	6,600	120	47	67,669	38,979	+28,690
Putnam	33,544	7,613	117	96	41,370	37,066	+4,364
Sullivan*	33,624	10,059	826	55	44,564	44,109	+455
Tippecanoe	49,339	14,657	544	120	64,660	79,497	-14,837
Vermillion	30,274	6,724	352	98	37,448	35,549	+1,899
Vigo	35,738	13,096	694	217	49,745	50,082	-337
Warrick*	30,088	9,609	62	40	39,799	33,171	+6,628
Washington*	17,245	19,028	77	68	36,418	30,206	+6,212

TABLE D.—*Acreage of various grains produced in 1888 throughout the area over which Chinch Bugs occur sometimes in destructive numbers.*

Benton	2,470	36,801	372	81	39,724	84,751	-45,027
Clay*	22,136	10,720	178	150	32,184	28,100	+5,084
Crawford*	9,527	7,216	13	10	16,766	14,502	+2,264
Daviess	39,049	11,194	280	75	50,598	39,259	+11,339
Dubois*	26,414	10,168	48	128	36,758	22,799	+13,959
Gibson*	68,640	5,606	466	116	74,828	48,280	+26,548
Green	30,962	12,627	253	84	43,926	35,745	+8,181
Jackson	27,425	14,135	254	34	41,848	43,007	-1,159
Knox*	47,798	6,869	222	163	55,058	54,001	+1,051
Lawrence	10,559	14,392	208	79	25,238	31,666	-6,328
Martin	14,450	8,797	124	126	23,497	20,928	+2,569
Monroe	10,147	8,500	64	22	18,733	16,241	+2,492
Orange	13,446	15,246	94	78	28,864	25,406	+3,458
Owen	13,329	10,402	82	43	23,856	17,422	+6,434
Parko	33,623	9,718	256	57	43,554	44,771	-1,217
Pike	30,934	10,154	54	106	41,248	32,062	+9,186
Posey*	59,006	7,465	108	39	66,618	46,711	+19,907
Putnam	32,139	8,194	131	74	40,538	39,358	+1,180
Sullivan*	29,377	11,279	798	68	41,522	45,808	-4,286
Tippecanoe	53,000	15,313	570	129	69,012	82,611	-13,599
Vermillion	29,985	7,710	439	76	38,216	35,444	+2,766
Vigo	36,157	14,327	557	203	51,244	52,084	-840
Warrick*	30,562	10,191	144	57	40,954	34,589	+6,365
Washington*	18,465	19,922	39	46	38,472	34,911	+3,561

* Counties marked with asterisk (*) are those in which Chinch Bugs have been reported in destructive numbers.

Much has been said of late of the influence which the cultivation of wheat and other grains has on the numbers and distribution of the Chinch Bug. Tables A, B, C, and D, here given show the acreage of each of the cereal grains in forty-eight counties for the years 1887 and 1888. It will be observed that among the uninfested counties there are but four which had a greater area of small grain than of corn in 1887 and in 1888. In 1887, in eleven of these same counties, the area of wheat exceeded that of corn, in six of which counties the Chinch Bug

is unheard of. Practically the same state of affairs existed in 1888, both as to crop and bugs. In the twelve counties more or less infested with bugs in 1887, four had a larger area of corn than of small grain, and all but seven showed a greater area of corn than wheat. In 1888 only three had a greater area devoted to wheat than corn, and six had a greater area of corn than of small grains. It will be observed that Sullivan County, which probably suffers from Chinch Bug injury as bad as any portion of the State, is one of these. It appears therefore that the nature of the crop has of itself nothing to do with the distribution of the Chinch Bug in Indiana.

TABLE E.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Princeton, Gibson County, Ind., latitude 35° 23' N., during the months of April, May, and June, for the years 1885, 1886, 1887, 1888, and 1889.*

Year.	April.		May.		June.	
	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.
1885.....	3.70	53.5	2.30	61.5	5.90	71.9
1886.....	3.50	55.3	2.10	66.1	4.90	71.3
1887.....	2.30	53.2	6.10	68.0	.10	74.3
1888.....	1.50	55.3	1.95	63.5	2.50	76.7
1889.....	.80	55.2	4.40	64.4	3.60	70.7

TABLE F.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Angola, Steuben County, Ind., latitude 41° 37' N., during the months of April, May, and June, for the years 1885, 1886, 1887, 1888, and 1889.*

1885.....	4.35	45.6	6.95	56.9	4.32	66.9
1886.....	2.77	52.5	3.49	63.5	4.16	67.2
1887.....	1.12	45.2	1.95	70.8	5.24	71.2
1888.....	1.64	46.5	3.75	61.9	5.16	70.6
1889.....	1.19	49.2	5.25	61.4	3.50	68.5

TABLE G.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Sandwich, De Kalb County, Ill., latitude 41° 31' N., during the months of April, May, and June of the years 1885, 1886, 1887, 1888, and 1889.*

1885.....	2.46	46.71	1.30	58.65	2.94	68.95
1886.....	1.35	50.40	3.06	64.70	1.28	68.82
1887.....	.57	53.12	1.87	68.55	1.77	75.07
1888.....	1.70	49.84	5.14	58.72	2.76	72.48
1889.....	3.15	52.03	3.08	61.71	5.40	68.62

Neither can this unequal distribution be attributed to the interspersion of timber lands among the cultivated fields, as the northern and southern portions are about equally wooded, and, besides, the treeless prairies of the State are not particularly subject to invasions of Chinch-bugs. Low temperature can hardly be held responsible for the phenomenon, as the ravages in more northern localities like Nebraska, northern Iowa, and in Minnesota will attest. Coming northward from the Ohio River, during the season of drought which has occurred each year since 1886, one can not help but admit that the effects of dry

weather are greatest in the southern portion of the State. But the difference between this weather condition is certainly not so marked between Tippecanoe and Benton Counties on the one hand, and La Porte and Lagrange Counties on the other, as to result in a difference in the number of bugs amounting to that between a great abundance and almost none at all. In Tables E, F, and G are given the mean temperature and rain-fall for the months during which these elements most affect the Chinch Bug, and extending over a period of five years.* This is as far back as the Indiana records extend. The records from Princeton, Ind., indicate the meteorological conditions during this period in the bug infested area, and those from Angola are a like record of the weather conditions in the region exempt from Chinch Bug attack, while Table G gives the meteorological conditions in De Kalb County, northern Illinois, where Chinch Bugs have been abundant since 1855, formerly doing serious damage to spring wheat, and have, since about 1862 (wheat of any sort being no longer grown to any extent), been transferring their attention to the corn crop, but being at present less abundant than in south-eastern Indiana or southern Illinois.

From a study of the tables given it will be seen that while the northern Illinois locality had a less rain fall during the spring and early summer than the northern portion of Indiana, it also had a less amount than had southern Indiana; yet, while Chinch Bugs are more numerous in the Illinois section than in northern Indiana, they are not so abundant as in southern Indiana.

Geologically, the northern portion of Indiana differs from the south-eastern portion, the former being Devonian and the latter carboniferous or subcarboniferous. This, however, could have little effect on the Chinch Bug, except, possibly, so far as it influenced the natural flora, especially the grasses. Prof. James Troop, who has made the grasses of Indiana a study, informs me that the following are all, or nearly all, the species found in the southern portion of the State which do not occur in the northern portion: *Uniola latifolia*, *Arundinaria tecta*, *Paspalum fluitans*, *P. laree*, *Panicum prolificum*, *P. anceps*, *P. rigidum*, *Andropogon divisisiflorus*.

From the foregoing it will be seen that to no one of these elements alone, as existing between southwestern Indiana and Illinois on the one hand, and northeastern Indiana, southern Michigan, and northern Ohio on the other, can this immunity from Chinch Bugs in these last localities be traced. Whether the combination of two of these elements, such as dry weather and wheat-growing, is to be held wholly responsible, or whether there is still another potent element, as yet unknown to us, which, either in itself or combined with some other, is the prime cause of the present state of affairs, only future studies can demonstrate.

* Kindly supplied me by N. E. Ballou, M. D., Ph. D., Sandwich, Ill., for thirty years volunteer signal observer at that place.—F. M. W.

That dry weather during spring and early summer is almost invariably associated with an increase, and wet weather during the same period with a decrease of Chinch Bugs is usually true, but why this is so has never been definitely explained.

The fungoid disease known as *Entomophthora* has, since it was studied by Dr. Shimer, been known to be much more fatal in wet than in dry weather. How far this would prove true, and to what extent the farmer could rely upon this fungus to keep the Chinch Bug in check, gave the incentive for carrying out the following experiments.

Early in July, 1888, a large number of Chinch Bugs, principally pupæ nearing the last molt, were placed in a close glass vessel and kept in a very damp atmosphere and under high temperature. Although kept for two weeks under these conditions we failed to produce the *Entomophthora* among them. This was accepted as evidence that the fungus did not exist in any stage of development here at La Fayette, Ind., although it was reported from an adjoining State.

On July 20, of the present year, we received some dead chinch bugs from Prof. F. H. Snow, of Lawrence, Kans., which were said to be affected by *Entomophthora*. These diseased bugs were placed under glass with living ones from the fields, the latter being provided with food and kept thus confined for fifty-three hours, when the major portion of them were placed on several hills of corn, seriously infested by bugs, the remainder with the dried remains received from Professor Snow being scattered about over a small area of young wheat sown for experiment, and also swarming with young Chinch Bugs. The hills of corn on which the bugs had been placed were isolated from others, equally badly infested, by narrow frames of boards placed on the ground, and the upper edges covered with tar. This last precaution was taken in order to prevent communication with other hills, intended as checks on those used directly in the experiment. The area of young wheat over which infested bugs had been placed was not inclosed, but its limits carefully marked. Five days after, July 27, a single bug was found on one of the isolated hills of corn which had very evidently died from the effects of *Entomophthora*, and by the 30th enough others were found to show that the fungus had fully established itself, and the barriers about the isolated hills were removed. On August 2, dead bugs covered with *Entomophthora* were found in considerable numbers about hills of corn, 25 feet from where the original colonies had been placed, and also throughout and even 55 feet beyond the area of young wheat over which dead and affected bugs had been distributed. Daily observations were now made, but the progress of the disease seemed to come to a stand-still. From the 5th of August up to the 9th it was almost impossible to get sufficient material, outside, to enable me to carry on laboratory experiments. August 13, the spread of *Entomophthora* appeared to have taken on new life, and diseased bugs were becoming much more numerous. August 15, found diseased bugs 172 feet from any place where they had been previously observed. August 20, diseased bugs were very abundant over all of

On the same day this experiment was begun, a second was also commenced, like the first in every particular except that the healthy bugs used, in experimentation, were exposed to fungus infested individuals for only five hours, and then placed under their respective glasses. As a result on August 15, thirteen days after, none had died, thus strongly indicating that the *Entomophthora* did not exist generally in the fields, and that it could not be communicated during a period of five hours, exposure.

On August 7 a large number of healthy bugs were placed under glass, with a number which had recently died from *Entomophthora*, the moisture in the vessel being absorbed by calcium chloride. A check experiment was also commenced, where the material and the conditions were the same, except the humidity of the atmosphere, care being taken to have the latter as nearly saturated with moisture as possible. August 10, the original experiment was divided and a portion of the healthy bugs removed and placed in a damp environment, the remainder being kept under the original dry conditions. The results on August 22 were as follows. In the original experiment, where the healthy bugs had been continually in dry quarters, not a single bug had died from *Entomophthora*. Not only this, but none of those which had been removed after three days and placed in dry quarters had died, showing that the disease was not contracted and did not develop in healthy bugs, though kept exposed in a dry atmosphere for fifteen days, nor could it be originated by placing, in a damp atmosphere, for twelve days, bugs which had been exposed to contagion for three days in dry quarters. The results with the check experiment were quite different. Within five days after being confined with the *Entomophthora*, the healthy bugs began to die from effects of the disease, and in three days more every one had died from the same cause, their bodies being covered with spores.

Still another experiment was tried which consisted in confining a large number of healthy bugs with others diseased in a damp environment, and when the fungus had destroyed a portion the remainder were divided and a part removed to dry quarters. The result was that while those left in damp confinement continued to die, none of those inclosed in dry environment were destroyed. As the fungus had by this time become distributed over the experiment farm so that I could not tell with certainty whether material from the fields was in a perfectly healthy condition or not, no farther experiments were made in this direction.

From the foregoing it will be observed that the essential element in all of these experiments was an abundance of moisture, without which the *Entomophthora* could neither become established nor flourish after it had gained a footing. Again the extent to which the disease will prove contagious will depend upon the number of bugs. Without great numbers massed together comparatively few would contract the disease. To sum up the matter there is little hope for relief to the farmer from the influence of *Entomophthora*, except when Chinch Bugs

are abundant and massed together in great numbers, and during a period of wet weather. I have succeeded in getting the fungus established at two widely located points in Indiana, and do not consider it at all difficult to introduce in localities where Chinch Bugs are abundant, provided the weather is favorable. But if it is ever utilized by the farmer, which seems to me to be at present a matter of considerable doubt, it will only be after the pest has become very abundant, during the time between the first larval and adult stages and in a wet time. After the *Entomophthora* has been introduced into a certain field it will become diffused only in proportion as the bugs travel about and healthy bugs come in contact with spores from those which have died from the disease. This will not be very great until the pupal stage is reached.

The larvæ of Chinch Bugs seem to in some way understand that while moulting they will be well nigh helpless, and hence hide themselves away in vast numbers in secluded places. Under such conditions the spores thrown from diseased bugs would reach a larger number of their fellows. I have found adults but recently moulted affected by the *Entomophthora*. After the bugs acquire wings and scatter themselves over the country, the liability to contagion will be again reduced, unless in case of very severe invasions, where from force of numbers congregating on or about food plants becomes a necessity. Hence, the introduction of the fungus among larvæ will at first proceed but slowly, and only in extreme cases and under favorable conditions can it be expected to proceed much more rapidly among adult bugs. In short, the only way that this fungoid disease seems capable of being employed in agriculture is by the establishment of some central propagating station to which farmers can apply and receive an abundant supply of infested bugs on short notice. By this means they could take advantage of a rainy period of a week or ten days, and, if they can contrive by sowing plats of millet and Hungarian to mass the bugs in certain localities about their fields, they might accomplish something towards warding off an invasion. But the possibility of overcoming an invasion after it is fully under way, as is almost sure to be the case during a dry season, it must be confessed is not very encouraging. My failure after repeated experiments to produce this *Entomophthora* in the vicinity of Lafayette without the importation of germs is decidedly against the theory that might be advanced that the northeastern portion of the State was kept free of destructive invasions by reason of this disease brought about by wet weather. There is as yet no reason to believe that the disease has ever existed in that section of the State.

Before leaving the subject it will be proper to state that in my experiments a larva of *Chrysopa* was introduced by accident and passed through the larval stage, feeding continually on bugs dying from the effects of the fungus.

After harvest the Chinch Bugs, as usual, transferred their attention to various grasses which were growing up among the stubble, more especially *Setaria* and *Panicum*, but as these succumbed to their contin-

ned attacks they transferred their attention to Timothy, and appeared to subsist equally well upon it.

At the date of wheat harvesting, fields were swarming with a species of lady beetle, *Coccinella 9-notata*, they having become excessively abundant by reason of the great numbers of the Grain Aphis, and as these disappeared the *Coccinella* was obliged to scatter themselves about and seek other food. As large numbers were found on stalks of growing corn infested by chinch-bugs, it seemed proper to determine the object of attraction to such places. The problem was in part solved by the fact that wherever great numbers of Chinch Bugs had punctured the corn plants the sap would exude from these punctured spots, and there the beetles would be found, singly or in groups of two or three, engaged in feeding upon the sap. Beetles placed under glass with a great number of Chinch Bugs refused to prey upon the latter, even when brought nearly to the point of starvation.

While searching under the sheaths of corn on several occasions larvæ and pupæ of a *Syrphus* fly were found, in many cases, right among the masses of young bugs. From some of these pupæ thus obtained we reared adults of *Pipiza pulchella*. Whether this species will ultimately prove to be an enemy of the Chinch Bug, it is too much to say, but the larvæ found by me could only have fed upon bugs or exuding sap, as they were near the roots of the corn where no pollen had collected.

THE GRAIN APHIS.

(*Siphonophora avenæ* Fab.)

Probably no insect has appeared in the State of Indiana for many years which caused such a general commotion among wheat growers, and which worked so little damage, considering, its numbers, as this.

Occurring every year in greater or less numbers, and having been frequently sent us by farmers, we were not at all surprised to receive specimens from Gallatin County, Ill., on May 27, and also a few days later from our aged friend Dr. Richard Owen, of New Harmony, Posey County, Ind. Probably about May 20 can be set down as the date of appearance, in numbers to attract attention in the extreme southern part of the State, the invasion terminating in the extreme northern portion about the 1st of July.

That the outbreak, which was probably the most severe since 1861 and 1862, should reach the magnitude that it did, both in point of numbers and area infested, was a surprise to me, as the preceding November had been spent by myself in traveling about, visiting the wheat fields of various portions of the State, these insects then being observed in no greater numbers than was usual at that season of the year. The winter following was an extremely mild one, which, taken with the statement of Dr. Cyrus Thomas,* that the insect passes the winter on grain plants in the fields, might lead to a misunderstanding as to the actual effect of mild winters.

* Eighth Rep. St. Ent. Ill., 1879, p. 53.

The winters of 1861 and 1862, the years of the serious outbreaks in New York and New England, though not particularly severe in the sections above mentioned, were by no means noted for mildness. It seems doubtful, therefore, if the causes leading to the invasion of the present year would carry us farther back than the spring months, a statement strongly substantiated by our own observation.

Starting, then, with the month of March we search for some meteorological element which might affect the increase of the Grain Aphis, and which appears both in the present season and also in 1861 and 1862.

TABLE II.—*General weather conditions in various localities during years of great abundance of Grain Aphis.*

Locality.	Year.	March.	April.	May.	June.
New York and New England	1861...	{ Cool.....	Cool.....	Cool.....	Cool.
		{ Average. Wet.....	Wet.....	Wet.....	Dry.
	1862...	{ Cool.....	Cool.....	Cool.....	Cool.
		{ Wet.....	Wet.....	Dry.....	Dry.
Indiana	1889	{ Warm.....	Warm.....	Cool.....	Cool.
Western New York	1889...	{ Dry.....	Dry.....	Dry.....	Wet.
		.....	.....	.....	{Cool. Wet.

The weather conditions as relating to New York and New England for 1861 and 1862, as given in Table II are based upon reports contained in the Country Gentleman for these years. Those for Indiana are based on the reports of the State Weather Service, and the data for western New York, for 1889, was given me by Prof. James Troop, Horticulturalist of the Indiana Experiment Station, who visited Livingston County in July.

From Table I, taken from Indiana Weather Service reports, it will be observed that during March and April the temperature was considerably above the normal, with the precipitation during this time below the average. On the other hand, the temperature of the months of May and June was much below the normal, with, as indicated by Table I, precipitation above the average. By referring to Table K, however, it will be observed that about half of the precipitation of May fell on the 29th and 30th of the month, thereby changing the apparent state of affairs, and practically throwing May into the dry period.

We have stated that the outbreak of the grain Aphis became conspicuous in southern Indiana and Illinois in May. It is also true that they reached their maximum numbers during the very last of this month and early June. In other words, they appeared during cool, dry weather, and disappeared in cool, wet weather. Thus far the old theory of entomologists, that wet weather is detrimental to their increase appeared true.

But it is also true, that while in southern localities they were disappearing during a wet period, in central and northern Indiana and western New York they were rapidly gaining in numbers, under precisely similar conditions.

Turning now to Table II, we search for an element common to the invasions of 1861 and 1862 and 1889, bearing in mind that in southern Indiana the pest arose to the maximum during May and early June, and in New York during June and early July.

TABLE I.—Comparative temperature and precipitation throughout the State of Indiana for March, April, May, and June, 1889.

TEMPERATURE (DEGREES—FAHRENHEIT).

Counties.	Stations.	Number of years.	March.		April.		May.		June.	
			Normal.	Departure from the normal.	Normal.	Departure from the normal.	Normal.	Departure from the normal.	Normal.	Departure from the normal.
Southern		5	41.1	+2.8	54.8	-0.1	64.4	-1.9	72.2	-2.5
Dubois	Huntingburgh	6	41.4	+4.6	54.6	+2.1	64.0	-1.4	72.8	-1.0
Gibson	Princeton	5	41.8	+4.7	54.1	+1.1	64.7	-0.3	74.0	-3.3
Crawford	Marengo	6	42.3	+3.1	57.7	+1.1	65.3	-0.9	72.2	-0.3
Washington	Salem	6	41.3	+0.2	53.2	-0.1	64.2	-0.1	72.2	-0.3
Switzerland	Vevay	21	42.8	+3.9	54.8	+1.3	65.4	-0.8	74.4	-3.5
Jennings	Butlerville	4	42.4	+2.9	55.5	-2.0	65.7	-4.0	73.7	-3.2
Greene	Worthington	6	39.6	+1.5	53.9	+0.9	63.9	-3.2	70.2	-2.4
Bartholomew	Columbus	6	38.4	+2.7	52.2	+0.2	63.4	-2.4	72.2	-3.7
Ripley	Summan	6	39.4	+3.0	53.4	+0.4	65.3	-3.0	72.5	-4.3
Warrick	Dagonia Springs	6	43.4	+2.1	55.8	-0.7	64.6	-2.5	72.0	-2.3
Clark	Blue Lick	12	42.9	+3.1	55.3	+1.14	64.5	-1.4	74.3	-2.3
Central		5	36.7	+1.9	51.0	+0.3	61.9	-1.0	70.4	-2.6
Johnson	Franklin	6	37.9	+5.1	52.0	+1.4	63.0	-1.2	70.8	-2.5
Fayette	Connorsville	7	37.8	+5.5	49.8	+3.0	62.6	-1.1	71.3	-3.6
Marion	Indianapolis	18	39.8	+2.8	52.5	+0.1	64.1	-3.9	72.5	-5.3
Rush	Mauzy	8	35.0	+6.1	49.2	+0.4	60.7	-1.2	68.7	-0.3
Henry	Spiceland	35	37.0	+6.0	50.0	+2.6	61.6	+0.7	70.5	-2.5
Wayne	Richmond	6	35.9	+2.0	50.5	-3.1	62.0	-4.1	69.5	-2.5
Randolph	Farmland	6	36.4	+6.0	48.7	+2.8	61.3	-0.3	69.7	-2.3
Delaware	Muncie	4	38.1	+5.2	52.3	-1.8	62.2	-1.1	70.0	-1.5
Northern		5	34.5	+3.8	49.9	-0.1	61.0	-2.4	70.0	-3.8
Tippecanoe	Lafayette	10	36.1	+1.7	54.7	-3.9	61.4	-2.1	70.0	-3.8
Carroll	Delphi	4	36.0	+1.7	51.6	-1.4	62.3	-2.7	70.0	-3.8
Whitley	Columbia City	4	34.7	+1.9	48.9	-0.9	60.0	-2.7	69.5	-5.6
Steuben	Angola	5	31.7	+6.3	47.8	+1.4	63.1	-1.7	68.9	-0.4
State		7	37.4	+3.9	51.9	0.00	62.1	-1.4	70.9	-3.0

PRECIPITATION (INCHES).

Southern		5	2.67	-1.49	3.26	-2.45	3.94	+1.56	4.07	+0.65
Dubois	Huntingburgh	6	3.28	-2.48	2.98	-3.30	3.92	+2.63	3.86	-0.24
Gibson	Princeton	5	2.45	-0.45	2.43	-1.63	3.09	+1.31	3.55	+0.05
Crawford	Marengo	6	3.25	-2.15	5.28	-1.68	6.00	+3.85	5.27	+1.25
Washington	Salem	6	2.62	-1.56	3.68	-2.58	3.24	+2.05	4.04	+0.61
Switzerland	Vevay	21	4.03	-3.20	3.40	-2.48	3.53	+2.64	5.07	-0.61
Jennings	Butlerville	4	3.35	-2.21	2.93	-1.72	5.56	+0.87	5.56	-1.85
Greene	Worthington	7	2.59	-0.58	3.04	-1.50	4.19	-1.29	4.51	+2.81
Bartholomew	Columbus	6	2.52	-1.65	2.60	-1.96	3.45	+1.35	3.50	+0.88
Ripley	Summan	6	2.45	-1.22	3.41	-1.77	4.38	+1.48	4.35	+1.61
Warrick	Dagonia Springs	6	2.92	-1.11	2.88	-1.90	3.06	+1.02	5.10	-0.61
Clark	Blue Lick	12	2.73	-1.86	3.65	-2.70	4.09	+1.46	4.04	+0.18
Central		5	2.33	-0.98	2.82	-1.46	4.19	+1.43	3.80	+1.08
Johnson	Franklin	6	2.45	-1.10	2.68	-1.47	4.04	+0.33	3.80	+2.20
Fayette	Connorsville	7	2.55	-1.70	2.32	-1.43	4.47	+2.12	4.37	-0.61
Marion	Indianapolis	18	3.85	-1.70	3.59	-1.47	4.15	+1.61	5.44	-0.76
Rush	Mauzy	9	3.50	-1.80	4.52	-2.44	4.89	+1.20	5.45	-0.75
Henry	Spiceland	35	3.90	-1.82	3.20	-1.52	3.35	+3.08	4.30	+0.40
Wayne	Richmond	6	2.38	-1.53	2.77	-1.95	4.21	+2.54	4.07	-0.33
Randolph	Farmland	6	2.18	-0.46	2.52	-1.45	4.42	-0.27	3.68	+1.91
Delaware	Muncie	4								
Northern		5	2.02	-0.14	2.03	-1.15	4.46	+1.24	4.12	+0.61
Tippecanoe	Lafayette	10	2.39	-0.70	2.78	-1.91	4.86	+1.55	4.91	-0.77
Carroll	Delphi	4	1.92	-0.74	2.16	-1.35	5.82	+1.43	4.46	-0.67
Whitley	Columbia City	4	2.01	+0.45	2.50	-1.45	5.17	+0.78	4.46	-0.67
Steuben	Angola	5	2.18	-0.18	2.21	-1.02	4.28	+0.97	4.48	-0.98
State		7	2.37	-0.86	2.70	-1.89	4.22	+1.28	4.16	+0.14

TABLE K.—Records of rain-fall throughout Indiana during May, 1889.

Place of observation.		Precipitation.						Number of days.					
Stations.	Counties.		Altitude above sea, in feet.	Latitude north.	Longitude west.	Total for month, including melted snow.	Greatest in 24 consecutive hours.		Snow-fall.	Cloudless.	Partly cloudy.	Cloudy.	On which rain or snow fell.
							Amount.	Date.					
Southern:													
Mount Vernon	Posey	a b	410	37 58	87 54	4.53	3.35	29, 30	In.	8	7	16	8
Huntingburgh	Dubois	a	...	38 21	86 59	6.55	3.55	29, 30	0	7	0	24	10
Princeton	Gibson	a	481	38 23	87 35	4.40	1.40	29, 30	0	14	13	4	7
Marengo	Crawford	a	...	38 24	86 24	9.85	5.70	29, 30	0	10	9	12	11
Salem	Washington	c	...	38 38	86 7	5.29	2.76	29, 30	0	14	8	9	10
Vevay	Switzerland	a b	525	38 47	84 59	6.17	2.60	29, 30	0	11	7	13	16
Butlerville	Jennings	a	...	39 3	85 33	6.43	4.02	29, 30	0	16	8	7	13
Worthington	Greene	c	540	39 9	87 0	2.90	1.86	29, 30	0	...	...	...	11
Seymour	Jackson	c	648	38 45	86 31	6.14	3.09	29	T	8	14	9	15
Columbus	Bartholomew	c	...	39 13	85 56	4.80	2.27	29, 30	0	9	10	12	12
Summan	Ripley	c	1018	39 14	85 6	5.72	2.60	29, 30	0	14	8	9	11
Degonia Springs	Warrick	a	...	38 6	87 12	4.04	1.45	29, 30	0	15	5	11	10
Cannelton	Perry	c	...	37 57	86 42	4.53	1.96	29, 30	0	12	7	12	10
Blue Lick	Clark	a	1009	38 32	85 50	5.55	1.78	30	c	10	10	11	10
Jeffersonville	do	a	...	38 32	85 50	5.55	3.43	29, 30	0	3	21	7	12
North Providence	do	b c	575	38 25	85 54	4.78	3.27	29, 30	0	10	4	7	11
Mean				39 30	86 13	5.17	2.62		0	11	9	11	11
Central:													
Franklin	Johnson	a	...	39 40	85 3	4.37	1.88	29, 30	0	8	0	23	15
Connorsville	Fayette	a	...	...	...	6.59	2.14	29, 30	0	12	4	15	12
Shelbyville	Shelby	a	...	...	...	4.65	2.15	29, 30	0	...	...	...	...
Indianapolis	Marion	a b	766	39 47	86 11	5.76	2.13	29, 30	0	6	9	16	15
Mauzy	Rush	b c	...	...	...	6.09	2.79	29, 30	0	...	...	...	14
Spiceland	Henry	a b	...	32 50	85 25	6.43	3.18	29, 30	0	6	20	5	13
Richmond	Wayne	c	969	39 51	84 53	6.75	2.68	29, 30	0	11	8	12	14
Rockville	Parke	c	722	39 46	87 10	5.75	2.61	29, 30	0	18	0	13	12
Farmland	Randolph	a	...	40 11	85 10	4.15	2.44	29, 30	0	8	9	14	7
Muncie	Delaware	a	...	40 11	85 25	...	...	...	0	20	0	11	8
Mean						5.62	2.44		0	11	6	14	12
Northern:													
Lafayette	Tippecanoe	c b	661	40 27	86 55	6.41	1.92	29, 30	0	11	6	14	12
Delphi	Carroll	c	589	40 36	86 41	7.25	3.87	29, 30	0	5	11	15	12
Marion	Grant	c	...	40 34	85 21	3.20	1.60	29, 30	0	...	...	...	7
Columbia City	Whitley	c	...	41 9	85 30	5.95	4.25	29, 30	0	...	...	...	7
Angola	Stauben	a	683	41 37	85 1	5.25	3.85	29, 30	0	10	5	16	7
Lagrange	Lagrange	a	980	41 37	85 26	...	...	...	...	...	...	...	...
Mean						5.70	2.91		0	8	8	15	9

SUMMARY.

	Precipitation.					Number of days.			
	Total for month, including melted snow.	Greatest in 24 consecutive hours.		Snow-fall.	Cloudless.	Partly cloudy.	Cloudy.	On which rain or snow fell.	
		Amount.	Date.						
Northern counties.....	5.70	2.91	.....	In.	0	8	8	15	9
Central counties.....	5.62	2.44	.....	0	11	6	14	12	12
Southern counties.....	5.17	2.62	.....	0	11	9	11	11	11
State.....	5.59	2.66	.....	0	10	8	13	11	11

The wet weather theory here appears broken, and a low temperature is the only element which appears uniformly through the months during which the Grain Aphis was, in all probability, increasing with the greatest rapidity. That cool weather should favor the development of these insects would, if true, be a new factor in the problem, not only of this, but other species also; and before leaning too heavily upon this evidence we should cast about for good reasons for this apparent ambiguity.

There is one very important element in this whole problem which we have so far left out of consideration, viz. natural enemies. While low temperature might not favor the development of the grain Aphis, or in fact, if the effect was slightly adverse, if the outcome was to destroy or retard the development of parasites, the ultimate result would be to favor the Aphis.

For myself, I can not get rid of the feeling that the indirect action of the weather of May and June—the action upon the parasites—was much greater than the direct effect upon the Aphis itself.

According to my field-notes, my earliest observation of the grain Aphis about La Fayette, lat. $40^{\circ} 27'$ N., during any year, was on April 27, and we have observed them during other years on grain early in May, in greater abundance than they were the present year on the 1st of June; yet in the former case no outbreak occurred. Up to the 1st of June, the Aphis was not exceedingly abundant on grain about La Fayette.

Even as late as the 7th their numbers on the heads of wheat were not so much greater than they had occasionally been in former years as to cause alarm; yet within ten days they were swarming in these same fields in myriads. This certainly bespeaks more of the effects of relief from the pressure of parasitism than from the effect of meteorological conditions, especially a change from dry to wet weather.

The question may be asked, why, if this be true, were not the parasites destroyed in the southern portion of the State, late in May, thereby relieving the Grain Aphis from this check on their increase, and why the latter by reason of this relief did not, as the wheat became too advanced, overrun the oat-fields, as would have at that date naturally followed. The reply is that such results did follow to a limited extent, the oats being rather more seriously infested by the Aphis than farther northward, and the reason why this feature was not more marked was doubtless owing to the fact that the cold waves of the first and last of May, especially the latter, were less severe than farther north, and the effect on the parasites correspondingly less fatal.

The records of the State weather service show that the minimum temperature of the first four days of May at La Fayette was below the freezing point; and on the 22d, 23d, 30th, 31st, from 34° to 39° Fahr. The mean minimum for the entire State for the same month, according to the same authority, was, for the southern portion, 36° Fahr., for the central 32° Fahr., and for the northern 30° Fahr.

Buckton (British Aphides, vol. 1, p. 70) has the following to say with regard to the effect of weather on this and other species of Aphides:

Violent changes of temperature seem much to check the multiplication of the Aphides. A cold rain, or the outburst of a thunder storm, will often cause the almost entire extermination of swarms, and wash them, never to return, from their native plants. Nevertheless, the close and hot atmosphere before a thunder storm seems to be peculiarly suited to their propagation. At such times the winged forms occur in great numbers and take flight on the gentle winds, which transport them many miles to other feeding grounds, to become the foundresses of other colonies.

The effect of the parasites on the Grain Louse was simply astonishing, while their numbers were myriads. Going to the fields of recently harvested grain, if one stood in a position to bring the newly made shocks between himself and the setting sun, he could clearly observe the swarms of minute Hymenopters arising therefrom and flying away. Besides, the stubble-fields were overrun with lady beetles and their larvæ.

Nevertheless, there are good grounds for the belief that the heavy showers during the latter part of June and early July, in the central and northern portions of Indiana, washed many young from the heads of the grain and destroyed them. Besides, either the severe thunder and lightning which accompanied these storms or the rapidly maturing grain, or both, perhaps, caused the winged adults to betake themselves to the oat-fields, where they would probably have caused further damage had not their relentless foes, the Hymenopters, pursued them and continued their work of destruction.

It was a common sight early in July, in northern Indiana, to see adults of the grain-lice attached singly to heads of oats, sometimes with a few young clustered about them, assuming the form and color so indicative of parasitism. In southern Indiana, late in June, the same thing was observed on oats, and parasitized adults were also abundant on the heads of blue-grass, even long distances from grain fields.

In summing up the matter, it may be safely said that wet weather will not, of itself, prevent an outbreak of the grain Aphis, or dispel it after under full headway. It must be borne in mind, however, that cool wet weather, during May and June, will enable grain plants to sustain greater drafts on their vitality than will very dry and hot weather. It is also probably true that a cool temperature during spring and early summer is either directly or indirectly favorable to the development of the grain Aphis.

Regarding the life history of the species under consideration we have never found them in the fields at an earlier date than April 27. From this time we have an unbroken record of their occurrence up to July 9, when there is a break in their continuity of appearance until September 1, when full grown apterous females were found on leaves of early sown wheat. From this latter date we again have an unbroken record up to December 30. We have also observed the sexes pairing on November 11 and December 3.

We have several times attempted to follow the species through July and August, but have always failed. Adults placed on various kinds of grasses in breeding cages invariably died during July. The occurrence of great numbers of wingless parasitized females on heads of *Poa pratensis*, long distances from grain fields, strongly suggest this grass as one of its midsummer food plants. While in this and other cases we have been unable to rear Aphides on certain plants in breeding cages, yet we do not feel at all certain but that outside, under the usual environments, nature might accomplish precisely the same object. The results of breeding cage experiments with Aphides must always be accepted with extreme caution.

The present year we had young grain growing continually from spring to November, yet not a single grain Aphis was to be found on either this young grain or grasses from July 9 to late in October. Their limited numbers at this season may, however, be accounted for by the fact that they were very nearly exterminated in July by their natural enemies.

Dr. Cyrus Thomas states that in 1875, in Southern Illinois, he observed winged and wingless specimens on wheat during winter, and suggests that the species winters over in other forms than the egg.* There appears to be no good reason for doubting the truth of Dr. Thomas' suggestion, especially if applied to mild winters. During the time we have been located in a wheat-growing district the winters have been quite severe, so that we have not been able to follow the species through the cold months. The winter of 1888-'89 was a mild one, but we were absent in Australia during the entire time.

Siphonophora avenae is by no means the only species of Aphides infesting the plants of our smaller cereal grains. An undescribed species of *Toxoptera* occurs on the leaves of wheat in the latitude of La Fayette, in June. We have carried this species through July and August on wheat in breeding cages, found it again in the fields in September, and from this on until the 22d of December. During the latter month they continued to reproduce in a room, which, though warm during the day, the temperature fell below the freezing point every night. I have not been able to follow the species through the winter months in the fields.

A species of *Aphis*, undistinguishable from *A. mali*, appears regularly every September, and, indeed, sometimes as early as July 17, on young wheat and rye. From the latter date up to the 12th of November they have been observed on young grain, giving birth to their young.

Notwithstanding the fact that the species is not distinguishable from the apple tree Aphis, yet the attempt to transfer them to the apple leaf, or vice versa, has invariably resulted in failures.

A second *Aphis*, as yet undescribed, is found about the roots of wheat, often in sufficient numbers to affect the plants. This species occurs throughout the entire State, from about the last of September, and

* Eighth Rep. St. Ent. Ill., 1879, p. 53.

probably winters over in the fields, in other stages besides the egg, although we have never yet found them on grain during the early part of the year.

An undescribed species of *Rhopalosiphum* was found on spring grown volunteer wheat, on July 12, of the present year. A few days later adults, both winged and wingless, and young in all stages of development, were found on the heads of orchard grass, *Dactylis glomerata*, and also on the heads of spring sown rye, working precisely after the manner of the true Grain Aphis. This species I was not able to follow in the fields after about the 10th of August, when it left the heads of rye, and, though a large number were placed on young wheat plants, in a breeding cage, all seem to have died.

When this last species was confined on wheat, the same cage and plants were utilized as had been used in the attempt to carry the true grain Aphis through the months of July and August. But as none of the many individuals placed on the plants survived, a large number of heads of rye thickly infested by the *Rhopalosiphum* were placed in the cage. When the first winged adult appeared in this cage, I was not a little surprised to find it belonged to neither one of the species intentionally placed in the cage, but to a species of *Myzus*, which could have only gained admission by being introduced with one or the other or both of the other species.

By whatever way it gained admission, this *Myzus* has continued to throw off generation after generation, and at date of writing, November 25, is still reproducing, although during the entire time—nearly four months—it has had no other plants except wheat upon which to subsist. It is undescribed.

Still another species (a *Megoura* sp.?) was found giving birth to young, on leaves of young rye, August 9, but not observed afterwards.

The natural enemies of the Grain Aphis were, as we might expect, unusually numerous the present year, and especially those belonging to the *Hymenoptera*. Of these we had reared, during other years, a species of *Trioxys* in quite abundance, and this season the following occurred in great numbers: *Bassus sycophanta* Walsh, *Aphidius avenaphis* Fitch, *Isocratus vulgaris* Walker, *Encyrtus websteri* Howard, *Allotria tritici* Fitch, *Megaspilus niger* Howard, *Pachyneuron micans* Howard.

Of the Syrphids, *Sphaerophoria cylindrica*, *Xanthogramma emarginata*, and *Allograpta obliqua* were very numerous. A secondary parasite, *Bassus sycophanta*, was in some localities so exceedingly abundant that nearly all of these useful flies were destroyed.

Two species of *Chrysopa* were exceedingly useful. In a field of wheat, near Indianapolis, about the middle of June, these were so abundant that at every step, from one to four or five individual adults would be disturbed, and take wing. The field was but very slightly attacked by *Siphonophora*.

Of the Coleopterous enemies, the *Coccinellidae* were by far the most industrious. Of this family probably *Coccinella 9-notata*, with its larvæ, was the most abundant and generally distributed species.

In a field of newly harvested grain, in La Grange County, within a radius of 3 feet from where I was standing at the time, fifteen individuals were counted, crawling about among the stubble. *Hippodamia parenthesis* followed next, in point of numbers, *H. convergens*, *H. 13-punctata* and *H. glacialis* being also found in quite large numbers in various localities. *Megilla maculata* was scarcely noticed at all, and *Anatis 15-punctata* but once.

Podabrus tomentosus was exceedingly useful in some portions of the State, while *Telephorus carolinus* was often quite numerous in the fields of the central part of the State.

ENTOMOLOGICAL NOTES FROM MISSOURI FOR THE SEASON OF 1889.

By MARY E. MURTFELDT, *Kirkwood, Mo.*

LETTER OF SUBMITTAL.

DEAR SIR: I inclose herewith such of my notes and observations on insects as may be of economic interest, and in this connection desire to express my sincere thanks for determinations and other assistance, for which I am indebted to yourself and to others of the official force of the Division.

Yours, very respectfully,

MARY E. MURTFELDT.

Prof. C. V. RILEY,
U. S. Entomologist.

GENERAL OBSERVATIONS.

The Cabbage Curculio (Centorhynchus rapæ).—A number of my correspondents in the central part of the State have informed me of the serious ravages of this insect in their hot-beds and vegetable gardens. Mr. F. M. Webster also wrote me, about the middle of May, that it had appeared in his garden in La Fayette, Ind. As yet I have not found it in Kirkwood or vicinity, and as it was with some difficulty that I obtained specimens for study, I have not been able to make such tests of insecticides upon it as would be practicable in the field. It promises to become a general and very considerable pest to the market gardener.

The Wavy-striped Flea-beetle (Phyllotreta vittata).—This insect appeared in great numbers this year in all parts of the State, being very destructive to peppergrass, early radishes, turnips, cabbage, and other *Crucifere* during the months of April and May. Mr. S. W. Gilbert, of Thayer, in the extreme southern part of the State, reported a loss of over fifty thousand cabbage-plants from the work of the larvæ on the roots. I could scarcely credit the statement that such extensive injury was attributable to this one insect until convinced by specimens of the pest, and of the injured plants which were excoriated and channeled on the surface of the roots from collar to tip, the foliage also being injured

by the mature beetles. A top-dressing of wood-ashes with a slight admixture of Paris green was recommended, but I was not informed with what results.

In company with this flea-beetle on the leaves of late radishes in our own garden, I was surprised to find great numbers of a species of *Podura*. I could not determine whether it produced any effect on the radish foliage independently, or why it should have appeared there so numerously.

Canker-worms (*Anisopteryx vernata*), except in orchards thoroughly plowed and harrowed the previous autumn, were quite abundant. Owing to the very warm winter, and consequent irregularity in emergence of the moths, cotton band traps, applied even as early as the first of March, did not capture as large a proportion of the females as usual. On some trees, therefore, the worms were numerous and where not killed by spraying were quite injurious.

The Plum Cureulio, which last year caused scarcely any damage to the fruits usually affected by it, appeared this season with recruited ranks; and on peach and plum trees, where spraying was not practiced, or where the frequent rains washed off the arsenites, a large proportion of the fruit was stung. As confirmatory of the single broodedness of the species, I observed that all the very late peaches, whether free or cling stones, even when so severely punctured on the surface as to prevent the development of the fruit, were entirely free from worms, showing that the cuts had been made for food only.

Aphididae.—It would seem as though all known and unknown species of this group of insects appeared in myriads throughout the Mississippi Valley, during the spring and summer. In many instances trees and shrubbery were killed outright by the punctures of their countless beaks, and the closing of the stomata of the leaves by their sticky exudations. So badly infested were the elms, maples, lindens, box-elders, and other shade trees, in and around Minneapolis, Minn., during the latter part of June that to pause or even pass beneath them was to endanger one's apparel from the honey dew that continually dripped from them, and from the black mold that soon covered trunk and branch and which "smutted" everything touching it. All other insects seemed to be repelled from the aphid-infested trees; not even a leaf-roller or leaf-miner could I see. In the September number of *INSECT LIFE*, mentioning the prevalence of *Aphis avenae* in the grain-fields of many of the Middle and Western States, I observe that Missouri was omitted from the list. The insect, however, occurred quite extensively in the middle and northern portions of the State, but it appeared rather late, and but comparatively little damage was done so far as I have been able to learn.

Syrphus fly, Coccinellid and Chrysopa larvæ waged a fierce, but, at first, unequal warfare with the tiny hosts, assisted by *Aphelinus* and probably other smaller as well as larger allies, so that as the season

advanced the *Aphididae* gradually disappeared and where seasonable rains followed the unfortunate plants measurably recovered, though the growth of trees and shrubbery was much retarded and distorted by them.

Codling Moth, not seriously destructive in the northern part of the State, but in the vicinity of St. Louis and in the southern counties, as I have been apprised by various correspondents, fully 50 per cent. of the fruit, on trees not sprayed, was destroyed by it.

The Stalk-borer (*Gortyna nitela*) committed its usual depredations in the leaf stalks of rhubarb and in shoots of blackberry and peach. Mr. S. W. Gilbert wrote me that it was so abundant in his young peach orchard that in the course of one walk among the trees he cut off twenty-five or thirty bored shoots. He says:

The worm seems to enter at the second or third bud from the tip and bore through the heart as far as the body of the tree but does not enter the hard wood.

In the flower garden this insect has done considerable damage by boring the stalks of dahlias, cosmos, and other flowers.

The Flea-like Negro-bug (*Corimelana pulicaria*).—Mr. E. S. Pollard, of Cameron, northwest Missouri, under date of May 22, sent specimens of this insect with the information that they were very abundant in his strawberry beds, and doing much damage by puncturing the bearing stems, causing the fruit to shrivel. As it was the fruiting season, I was at a loss to suggest a remedy, since this insect is not susceptible to the effects of pyrethrum, or other non-poisonous applications. In Kirkwood it appeared in great numbers on hollyhocks and various other flowering plants, for which the easiest remedy seemed to be to jar it into basins of soap-suds to which had been added a small quantity of kerosene.

Lygus lineatus appeared here and there on tufts of clover, about the middle of May, injuring the foliage to considerable extent. It inhabits the under surfaces of the leaves which it speckles with transparent dots and small patches which cause the leaves to curl and shrivel. Its broad, flat larva is of a dull, pale green color, variegated with a few ferruginous marks and shadings. The pupa is very similar, with the addition of the wing-pads.

The Tarnished Plant-bug (*Lygus pratensis* Linn.).—This insect was more abundant than usual throughout the State, and from numerous correspondents I received bitter complaints of its injuries to apple and pear buds and to strawberry beds. During the autumn it appeared in considerable numbers on chrysanthemums, on which its peculiarly poisonous punctures produce most disastrous effects. I was quite successful in driving it from our own plants by liberal applications of N. O. dust, which proved at the same time a good remedy for the brown aphid, which is such a common and unmanageable pest on these beautiful flowers. The plants were not injured in the least by the insecticides.

The *Streaked Cottonwood beetle* (*Plagioderma scripta*) appeared in our grounds during June on a young *Populus*, which it threatened to completely defoliate. The tree being small admitted of thorough drenching with a plant syringe with the solution of arsenic and ammonia—1 ounce of arsenic in 1 quart of aqua ammonia—1 tablespoonful of the solution to a gallon of water, by which means and a little hand-picking the pest was so thoroughly exterminated that it did not reappear later in the season.

The 12-spotted *Diabrotica* (*D. 12-punctata*) was a serious pest during the latter part of the season, not only on squash and cucumber vines, but on late sweet-corn, and especially in its injuries in the flower garden on the blossoms of roses, dahlias, and cosmos on which it literally swarmed. To save the flowers it was necessary to make the rounds two or three times a day and capture or put the beetles to flight. They were not much affected by any of the milder insecticides, and the arsenical remedies could not very conveniently be applied.

The *European Cabbage-butterfly* (*Pieris rapa*) acquires one or more new food plants annually and threatens to become quite omnivorous. This year it proved in several localities very destructive to nasturtiums (*Tropaeolum*) both in flower and vegetable gardens. None of its parasites have yet appeared, so far as I have been able to ascertain. It seems to have entirely supplanted our native *P. protodice* in this locality. Wishing to obtain some larvæ of the latter for a certain purpose, I made many examinations during the summer of the neighboring cabbage plantations, but did not succeed in finding a single one.

SPECIAL STUDIES.

THE SPINACH BEETLE.

(*Disonycha collaris* Fabr.)

About the middle of April I observed the leaves of spinach in the garden were badly perforated, and, upon examination, I found on the under surfaces numbers of small, dingy, white larvæ, evidently of some Chrysomelid beetle. They reposed in the numerous depressions between the veins, and a slight shake or jar caused them to drop to the ground. The insects increased in size and numbers until by the middle of May all the leaves were badly injured and the gardeners hereabout complained that their spinach was so "worm eaten" this year that they could no longer offer it for sale. A few of the same larvæ were also found on young beet leaves, especially of the white and yellow varieties, and upon the wild *Chenopodium album*, the latter being, I suspect, the original food plant of the insect.

As the larvæ drop so quickly upon being disturbed, it is not often that they are observed by the gardener or cook, and the damage was attributed by many to "some kind of cut-worm." By plucking the

leaves, carefully, however, as many as fifteen or twenty "grubs" were sometimes found on a single leaf.

April 24 I collected a large number, which were placed in a jar in order that their development might be more closely watched. Most of these were still very small, only from 3 to 4^{mm} in length. When very young they merely gnaw the under surface of the leaf, noticeable on the upper side as small discolored spots, but as they increase in size they eat entirely through both cuticles, making large roundish perforations.

It is probable that there are but three larval molts, as, in the case of even the smallest larvæ under observation, I was able to note but two, and infer that one had been passed before they were brought in.

The larger larvæ entered the ground the 4th, 5th, and 6th of May, penetrating to a depth of only from one-fourth to one-half an inch and inclosing themselves in frail, nearly spherical, cocoons or cells of earth cemented with a viscid secretion. Larvæ, however, were found on the spinach throughout the month of May.

May 25 one of the beetles emerged, which proved to be *Disonycha collaris* Fabr.; and from this time until after the middle of June bred specimens continued to come out.

A package of specimens was sent to the Department in case it should be considered desirable to have drawings made of the different stages of development. Unfortunately this consignment did not reach Washington, and I did not learn of the failure until too late to replace it. Specimens were, however, preserved in alcohol, which retain all the important characters.

No account of the immature stages of the insect or of its spinach-feeding propensity is to be found in any work on economic entomology to which I have access, and I think it has not heretofore been recognized among the pests of the vegetable garden. I therefore subjoin the following descriptions.

Egg, not observed.

Mature larva, from which the young differ only in size, 9^{mm} in length, 3 to 4^{mm} in diameter; form subcylindrical, tapering slightly each way from middle segments, which, both in resting and crawling, appears somewhat elevated or "hunched up." Color a dirty, rather livid white, with a shiny, slightly viscid surface, each segment produced with ten conical papillæ—lateral ones largest—each of which terminates in a minute bristle. Head about one-half the diameter of the thoracic segments, oblique, circular, corneous, fulvous, paler in front, with dark brown mouthparts and two dark brown, somewhat elevated, spots on each side. The posterior end of the body terminates in a dark brown, corneous wing, most pronounced on the dorsal side, fringed with bristles. This is always appressed to the leaf, and in moving the bristles assist in propulsion. Legs concolorous with general surface, but with fulvous or dingy brown annulations, the terminal joint being entirely of the dark color.

Pupa, 8^{mm} in length, 3 in diameter across dorsum, with elytra and wings partly extended as in other pupæ of *Halticina*; the legs drawn up and folded close against the body. Color pearly white in all its parts, acquiring a translucent gray tinge before the last transformation.

Beetle quite pale at first, gradually acquiring the dark metallic green of the elytra, buff thorax, dark legs and under surface and other colorational characteristics of the mature insect,

This species seems to be but single brooded, as no young larvæ were to be found after the first of June. As, however, the spinach beds were rooted out before midsummer in all the gardens of the vicinity, I can not be quite certain upon this point, but could not discover it on beets or any of the native *Chenopodiaceæ*. The insect is one to which it is difficult to apply insecticides, as the leaves which it attacks lie close to the earth and it is, as a rule, on the under side.

NEW ROSE SLUG.

(*Cladius isomera* Harris.)

Early in August a friend, residing at St. Charles, Mo., sent me specimens of a Tenthredinid larva that was working on her rose bushes, especially on climbers. This species, new to me, devours the entire substance of the leaves, gnawing into them large ragged holes and webbing them together in the formation of its cocoons, greatly injuring and disfiguring the plants. It is characterized as follows:

Mature larva 12^{mm} in length, 3^{mm} in diameter across thorax, from whence it tapers very slightly backward; form cylindrical. Color, pale bluish-green, surface clothed with tufts of soft gray hairs. Head opaque, dull whitish green, under the lens densely mottled with pale, ferruginous, small black dot, above which is a rectangular ferruginous spot on each side. Twenty legs, concolorous with general surface. Spins up between folded leaf or between two leaves, in glassy, gummy, pale brown cocoon, 7^{mm} long, of an oblong shape, flattened on both sides against the inclosing leaves and with many gummy threads spreading in every direction.

Cocoons were formed in rearing cage August 20. Flies appeared August 29. On the 2d of September I detected two in the act of ovipositing, with their well-developed "saws" deeply buried, one in the midrib, the other in the petiole of a fresh leaf. Two or three minutes were occupied in the placing of an egg and each fly put in three or four without pausing to rest. By carefully detaching the surrounding fibers the egg was revealed. It is oblong, scarcely 1^{mm} in length, and almost transparent. These eggs failed to hatch, probably for lack of fecundation.

From what I have learned from my friend, and infer from the habits of the insect in the rearing cage, there are an indefinite number of broods during the summer, and where it has become established it is therefore a more serious pest of the "queen of flowers" than even *Selandria rosa*. I do not doubt, however, that by killing off the earliest broods with drenchings of an infusion of white hellebore, it could be kept in check and by perseverance in the treatment eventually exterminated. I have not been informed of its occurrence in any other part of the State.

THE WHITE FRINGE SLUG.

(Scandria ? sp.)

The White Fringe tree (*Chionanthus virginica*), in its season one of the most exquisite of flowering shrubs or small trees, is subject to the annual attack of a medium-sized, spiny slug that perforates the leaves with small round holes after reducing the greater number of them to mere lace-work. This species is single brooded, but the parent flies appear irregularly and larvæ may often be found from the latter part of April until the end of May, in the interval seriously disfiguring, often killing, the foliage. It lives on the under side of the leaves and feeds chiefly at night. Full grown larvæ from 9 to 12^{mm} long, 3^{mm} in diameter across the thoracic segments, form cylindrical, nearly equal throughout, or tapering slightly backward from thorax. Color greenish-white, surface very rugose, dorsum and sides quite thickly beset with bifid spines, those on dorsum jet black, arising from velvety black spots and being largest in the subdorsal region; lateral spines pale. Head about one-half the diameter of thorax, almost spherical, jet black, immaculate. Legs, 22 in number, concolorous with general surface, and unusually well developed. With me it has proved a difficult species to rear, and I confined the larvæ for several successive seasons without getting a single fly, and last spring but two from a large number of larvæ developed. In the rearing cage, after ceasing to feed, the larvæ desert the leaves and wander restlessly around the cage, many of them dying without entering the ground. The few that transform inclose themselves in very brittle, nearly spherical cells about an inch below the surface, and as with most other saw-fly larvæ that enter the ground brook no disturbance during the quiescent period. The two flies that I succeeded in rearing came out about the middle of April.

Syringing the under sides of the leaves with a strong infusion of white hellebore, or with Paris green in liquid suspension, will kill the pests, with but little detriment to the foliage.

DESCRIPTION OF THE LARVA AND PUPA OF *PALTHIS ANGULALIS*.

Among the insects trapped last spring in loose cotton around the trunks of apple trees were a considerable number of a dingy-colored noctuid larva, about 1 centimeter in length by 4^{mm} in diameter, of nearly equal width throughout, the segments appearing somewhat hunched together. Surface rough, of an earthy-brown color, palest on dorsum. Under the lens, especially after being dropped in alcohol, a tinge of green appears, and the paler cast of the dorsal surface is resolved into a spreading V composed of minute white stippling. This is especially pronounced on the posterior segments, where the angle of the V is developed into a papillate elevation. Head small, much retracted, dark brown; legs and prolegs, and also to some extent the entire ventral surface, verdigris green. These larvæ were found from the 1st to the 5th

of April, and, when placed in the cage with opening apple buds, nibbled a little, but almost immediately changed to pupæ within a cluster of webbed leaves. Pupa smooth, dark brown, without any especially distinguishing characters. Three imagines appeared April 24. They were of a species which had been long before determined for me as a *Palthis angulalis*.

With the idea that possibly the immature stages of this insect had not previously been observed, I submit the above descriptions.

INSECTICIDES.

White arsenic in ammoniacal solution—1 ounce arsenic to 1 quart aqua ammonia—one tablespoonful of this to a gallon of water proved a failure in the case of most insects, while it still scorched the leaves somewhat.

A soda solution made on a smaller scale had much the same effect on the foliage of peach and plum trees, and was not, so far as could be observed, efficient in protecting the fruit from curculio.

White arsenic in boiling water, the latter being only a partial solvent, in the proportion of an ounce of arsenic to 20 gallons of water, was sprayed upon young peach and plum trees without injury to the foliage. The frequent rains of the late spring and early summer rendered many of the applications futile in the case of the curculio and codling moth. Paris green in liquid, 1 pound to 100 gallons of water, has been found the safest and most reliable insecticide for use against the canker-worm and codling moth. Its effects on insect life seem to be due not alone to the percentage of arsenic, but to the general combination, while on vegetation it produces less injury than London purple or any of the solutions of pure arsenic.

In my somewhat limited experience the petroleum emulsions can not be excelled as a remedy for all species of scale insects, and when applied according to instructions, do no appreciable injury to trees and shrubs.

N. O. Dust.—Late in May I received from the Department a package of this new patented insecticide, with instructions to test its value on various injurious insects. It is to be applied full strength and claims to kill by contact and at the same time to be innoxious to man and the higher animals and to vegetable life.

June 1.—Applied the powder about 9 o'clock in the morning to *Doryphora* larvæ on potato, to late specimens of the rose-slug (*Scandria rosea*), to *Aphis persica* on young peach and plum trees, and to *Aphis* sp.? on chrysanthemums; also to young cabbages and radishes, on which flea beetles (*Phyllotreta vittata* and *zimmermanni*) were abundant and destructive. Three hours later visited these plants and noted following results: Rose-slugs considerably affected, showing symptoms of sickness and paralysis and dropping from the leaves when jarred. *Doryphora* larvæ not seriously affected, only the smaller ones had dropped, while some of those nearly grown continued feeding, appar-

ently not inconvenienced by the dust that adhered to them. Flea beetles not killed, but evidently demoralized and deserting rapidly. Its effects on *Aphididae* were quite satisfactory. All species to which it had been applied seemed to be killed or paralyzed and had withdrawn their beaks from the stems or leaves, and if they had not already fallen did so upon the slightest jar. At the same time *Chrysopa* and *Coccinellid* larvæ appeared but little, if any, injured, and were seen making their way to other hunting grounds on which the game should not be so pungently spiced. Syrphus-fly larvæ, however, did not escape, and all that received much of the dust were killed.

At 7 in the evening more of the powder was distributed on infested potatoes and on all species of *Aphis* that could be reached.

June 3.—The effects of the Dust on the Colorado potato-beetle are by no means so immediate and thorough as claimed in the circulars of the manufacturers. Repeated applications would seem to be necessary to kill the larvæ, while according to my experience the perfect beetle will live for days thoroughly dusted with the powder and inclosed in a box. At the same time it certainly does protect the plants to which it is applied, especially while fresh, by acting as a repellant.

September 10.—Tested the Dust on larvæ of the cabbage butterfly which are beginning to be found again in cabbage fields. Used the insecticide in the open air, also on a few full-grown larvæ placed in jar, under muslin cover.

September 15.—Plants dusted seem almost entirely free from worms, but several of the larvæ confined completed their first transformation without apparently receiving any injury from the powder.

September 21.—Repeated these tests with powder taken from the bottom of the can and found that young *Pieris* larvæ succumbed to its effects in two or three hours, while the larger larvæ often lived more than twenty-four hours, not eating, however, in the mean time, but lingering in a lethargic state until dead.

October 19.—Renewed these experiments on the latest brood of worms which are now to be found of all sizes on cabbages, turnips, and nasturtiums. The immediate effect of the powder is to cause the larvæ to cease feeding and toss themselves about uneasily, making efforts to free themselves from the irritating substance. Two hours later all were in a lethargic state, many lying upon their sides in the folds of the leaves and on the ground. They would squirm when touched, but gave no other sign of life. Twenty-four hours later all the small larvæ were dead; the others that had passed the second molt still lived, but were inactive with a sickly color. Forty-eight hours afterward all were dead. From these tests and experiments I conclude that this X. O. Dust may be classed with reliable remedies for this and probably other Lepidopterous cabbage pests, its value being nearly equal to that of Pyrethrum powder.

This remedy was also used on Tarnished Plant-bug with the effect of

driving it from the dusted plants, although bugs confined in a box with it would survive several days.

The little *Halticus pallicornis*, which was this year very troublesome, not only in the clover fields and vegetable gardens, on beans, cucumbers, etc., but was especially destructive to asters, was also routed by having this powder puffed on the under side of the leaves; the young bugs were killed and the mature ones driven away.

The Dust was further tested on a few late cut-worms, *Agrotis saucia*, *Celana renigera*, and some other species which I can not name, but without much effect, as the powdered worms in the course of an hour all crawled out of the deep box in which they had been confined and escaped.

All hairy larvæ, as in the case of *Pyrethrum*, seemed insensible to its effects, so also did the striped and twelve-spotted cucumber beetles and other mature Coleoptera and the squash-bug.

There are quite a number of injurious insects on which I did not have opportunity to use it, and on which I hope to experiment with it another season.

From my experience with it this season I should rank it among the second-class insecticides, producing similar effects, but not quite equal to the California Buhach, but still valuable for use against certain insects on which it is not safe or expedient to employ the arsenates.

NOTES ON PHYLLOXERA RILEYI FOR 1889.

June 15.—Received instructions through Mr. Howard to collect and prepare specimens of *Ph. rileyi* in all its stages in fluid and in balsam on microscopic slides.

The post-oaks (*Q. obtusiloba*), on which the insect chiefly occurs on the place, were found to be less abundantly infested than during other years. The first leaves which have attained their growth and are beginning to toughen are, however, considerably speckled with their punctures, especially along the midrib and principal veins. Very few besides the pale yellow, smooth, elongate forms are noticeable.

Put up a number of infested leaves in alcohol reduced about 60 per cent. with water. (These I afterwards learned from Mr. Howard did not keep, the alcohol being perhaps too strong). I also prepared slides.

July 22.—Have just returned from Minnesota. Sent slides on to Washington. Examined leaves of post-oak around home, but found no winged *Phylloxera*, and very little change in the specimens on the leaves during the last month.

Among other insects preying on the aphid is *Eucanthus latipennis* in noticeable numbers, one or more on the under side of nearly every leaf. They are now nearly full-grown larvæ. The puzzle is how they come to be on the oaks, when I have never found their punctures in the twigs and when some of the trees are at quite a distance from raspberry or grape vines, in which they mostly deposit their eggs.

July 29.—After driving about the country in several directions I

found on the roadside about a mile from town some post-oak sprouts on which *Phylloxera* abounded in all stages of development. The pale smooth variety was most numerous on the older and tougher leaves, while the darker, tubercled larvæ and pseudo-pupæ and a few winged specimens crowded the unfolding second growth. The young leaves were much curled and distorted by their innumerable punctures. The aphids were preyed upon by the larvæ of the green *Chrysopa* and of one or two small Coccinellids; the deep red larvæ of a small Thrips was especially active and numerous among them, as also was the whitish gray larva of a small bug (No. 3 of my consignment of October 2).

Put up specimens on slides and sent some alive to Mr. Howard in tubes; also some in alcohol. I also placed winged individuals in three different sizes of tubes and on clean leaves in water in a glass jar.

August 3.—Notwithstanding all my care all the winged lice perished without leaving any eggs, to my great disappointment. Probably the extreme heat of the weather was unfavorable. Cleaned and disinfected my tubes and put in fresh winged forms and closed the tubes with loose cotton instead of cork to prevent excess of moisture.

August 3.—Another failure. All the specimens dead and molded and no eggs. I can not understand it.

August 15.—Made another excursion out into the country and succeeded in obtaining a very few. Nearly all the young oaks so badly infested two weeks ago are entirely cleared, probably by the migration of the winged forms and the destruction of eggs and wingless forms by predatory insects. The tender shoots are also killed and stand up stiff and dry; the drought being severe, there was no opportunity for them to recover from the attacks of the aphids.

On the lower mature leaves the insect still abounds in its wingless forms, mostly the flat, pale, smooth variety. Put seven of the winged aphids into a very small tube with a bit of mature oak-leaf and closed it tightly with common cork. (The rubber corks kill all insects inclosed with them very shortly, probably with their sulphurous emanations.) Also put about a half dozen on growing sprouts of oak, out of doors, but which seemed to be entirely free from infection, inclosed under fine muslin cover.

August 17.—Have at last succeeded in getting nine eggs in the small tube. These eggs do not differ much from those of the ordinary apterous form. On close comparison they seem rather more opaque and of a deeper yellow tint than the latter, but even in these particulars there is some variation. Each individual produces from one to three eggs; and usually perishes beside them.

August 21.—Eggs still healthy and beginning to show segmentation with two red eye-spots on the cephalic end. There is evidently a slipping backward of the thin pellicle that incloses them, although as yet no motion is discoverable. The eggs were all laid on the glass and not on the portion of the leaf inclosed with them.

August 22.—Three *Phylloxera* have hatched from the eggs and one

has crawled quite a distance. The egg-shells or pellicles are left as an almost transparent round dot at the place of hatching. Nearly all the substance of the egg seems to be absorbed into the young aphis. Inserted a bit of fresh young leaf, but they do not seem to be attracted to it, and remain crawling on the glass.

August 23.—Two more have hatched. They appear all alike so far as can be ascertained with a lens. Three were sacrificed for microscopic examination. Have the specimens under almost constant observation, but am not able to find them pairing or exhibiting any sexual attraction. Neither can I induce them to feed on even the tenderest bits of leaf. They appear precisely like the parthenogenetic forms through my lens, which is not sufficiently powerful to resolve the mouth parts and genitalia.

September 1.—Only two still alive and no eggs. Transferred the survivors as carefully as possible to fresh leaf and placed in clean tube.

Examined inclosed leaves out of doors but could detect neither eggs nor larvæ. It is an almost impossible task to keep track of such microscopic creatures in the open air.

The wingless lice have now become quite abundant on all our post-oaks. I do not find them on the white oak proper, but as I have examined them almost daily since the middle of July I am confident that none of the winged individuals occurred on any of the oaks on the place. I believe they never do occur in any numbers except on the more succulent growth of sprouts where living trees have been cut.

September 10.—All my progeny of winged lice have perished without leaving a single egg. Made another excursion into the country but obtained only two or three winged individuals which I put in tube, but of which I do not entertain much hope.

On one of the leaves out of doors, isolated about a month ago, I find by critical examination a very few minute specimens which are probably the progeny of the winged forms inclosed. Put some in balsam, though I can not see that they differ from the other wingless young on exposed leaves.

September 15.—No success with the last inclosure in tube.

October 25.—Have had one or two quite hard frosts. Leaves all turned in color, and *Phylloxera* becoming very active, congregating along principal veins and migrating on to the twigs. Their insect enemies have mostly disappeared and I notice that eggs are more plentiful than usual on the leaves.

From my observations this year I incline to the opinion that the winged form is necessary merely for the spread of the species, and that the young from the eggs of this form are not necessarily true-sexed individuals, although it is possible that these may occur without any especial regularity from the eggs of both winged and wingless forms.

Another year, if nothing happens to prevent, I will try to have some oaks in flower pots for more convenient and natural colonization of the *Phylloxera*, and for greater ease in examination.

REPORT ON CALIFORNIA INSECTS.

By ALBERT KOEBELE, *Special Agent.*

LETTER OF TRANSMITTAL.

ALAMEDA, CAL. *October 25, 1889.*

SIR: I herewith submit my report upon observations made and work done since my return from Australia.

After returning to Alameda on April 15, some time was taken up in writing out my reports upon work done in Australia, and also in assisting in raising and distributing in the northern part of this State the Australian Ladybird-enemy of the *Icerya*. This Ladybird does remarkably good and speedy work everywhere. As usual my chief work has been the breeding and studying of all insects, injurious and otherwise, that have come under my notice, the special notes on which will accompany material that will be sent in.

Respectfully,

ALBERT KOEBELE.

Prof. C. V. RILEY,
U. S. Entomologist.

THE MADRONA TREE BORER.

(*Polycæon confertus* Lec.)

This destructive beetle occurs to a greater or less extent every spring and summer upon various fruit-trees, vines, etc., boring into the fresh wood and destroying it. During my stay in the Santa Cruz Mountains the past summer they were observed everywhere, and most abundantly during May and June. On any dead tree, as soon as the leaves begin to fade, this beetle may be found, though always most abundantly upon the Madrona tree (*Arbutus menziesii*). Old trees of this species, such as have been allowed to lay on the ground for a year or two, are always completely perforated with holes from which these beetles have made their exit. In cutting through, one finds the wood nothing but mines produced by the larvæ, the mines generally running lengthwise, but often crossing each other. The Madrona tree seems to be the ordinary if not the only plant in which the beetle breeds. Notwithstanding that the mature insect bores in almost any kind of fresh wood, and especially favors such as has been somewhat injured by the hot sun, the larvæ is

not, or has never yet been, found in such places. It is the general belief here that it breeds in the wood of Oak, yet, so far as my experience goes, its larvæ are never found in other than the Madrona wood. It is very remarkable, in view of the above, that they should live and transform within apples from which this beetle has been bred.

On August 2, 1887, at St. Helena, Cal., a large number of the nearly grown apples upon trees in a private garden were observed to be dead and yellowish brown. One of these, taken to Alameda and examined, proved to contain a small whitish Coleopterous larva. This was living and thriving on the dead and dry apple until April 16, 1888, when it transformed to a pupa, from which the mature beetle issued on April 28. Since then no infested apples have been observed, nor have I seen any of the large fruit in the condition described above. The work of these beetles was witnessed in the Santa Cruz Mountains May 25, 1888, chiefly upon grapes and plums, yet they will attack olives and other trees as well. In many cases the shoots of grapes are cut off entirely and fall to the ground, where either one or both sexes may be found at work. In one case I noticed a plum tree the northern branches of which were entirely destroyed. The beetle will often make several holes into the center of a branch before entering; no doubt being compelled to leave on account of the copious flow of sap. Seven such holes were found in one branch, in the lowermost of which the beetle had entered and formed a tunnel of about 3 inches in length. On the other branches, aside from the many holes started, but two tunnels were found and no insects were present. This will show that one of these beetles alone is capable of disfiguring an entire tree, while two or three specimens can destroy a tree.

As a remedy, the recommendation of clearing and burning the dead Madrona wood alone would certainly have a most remarkable effect in reducing the numbers of this beetle.

(*Chrysobothris mali* Horn.)

The larva of this Buprestid is very destructive to currant bushes. It is found in the Santa Cruz Mountains, at least in such numbers as to destroy all the plants. Indeed, it is impossible to raise this fruit in that district on account of this insect. They have not been observed as yet in the valleys, where in their place *Egeria tipuliformis* Linn. is more numerously represented upon this plant than in the hills. As many as fifteen or even twenty Buprestid larvæ may be found within a single plant, the stems of which naturally die and break off near the ground. The beetle is found most abundantly during June and July, when they can be seen resting on the plants generally near the ground during sunshine. It is then that they lay their eggs on the lower part of the branches and close to the ground where most of the larvæ are found. Eggs are also placed at a height of 2 feet, or even more, according to the size of the plant, and below the ground to the depth of

several inches. Where the larvæ are very numerous the plants will die before the larvæ are grown, and most of the latter will perish; only such as are situated near or below the ground will survive. Empty pupæ of two species of parasites were observed within the burrows of the larvæ, both apparently belonging to the Ichneumonidae.

As a remedy, the collecting of the beetles may be recommended. During early morning and evening they may be found either on the currant bushes or the surrounding trees, almost always at rest on and within dry and dead leaves from which they can be shaken into an umbrella. During their operations upon the plants in the day-time it is difficult to get near them as they are very quick on the wing and exceedingly shy. Collecting and burning the infested plants during winter, and also the whitewashing of lower parts of plants may have a good effect; this should be done about the end of May.

(*Diabrotica soror* Lec.)

This beetle occurs occasionally in such numbers as to become exceedingly destructive to fruits and vegetables. As yet the earlier stages have not been studied. All attempts to get eggs and larvæ have so far been a failure on my part as well as on the part of other entomologists. A large number of the beetles were kept in confinement for weeks with various living plants without any results. The larva, without doubt, will be found to have the same habits as the other species of the group,—feeding upon roots of various plants. Fortunately this insect is preyed upon by a dipterous larva, which without doubt destroys the greater number of them, in certain years at least. As early as 1886, while at Los Angeles, Mr. Alexander Craw, of that city, showed both Mr. Coquillett and myself the larva infesting this beetle. I did not succeed in breeding the same until June last, and Mr. Coquillett reports recently of his partial success in this particular.*

THE TENT-CATERPILLARS.

(*Clisiocampa* spp.)

From year to year these worms become more and more numerous upon fruit trees. Mr. Stretch in his paper on the genus† cites six species as occurring on this coast,—*C. californica* Packard, as feeding upon *Quercus agrifolia*; *C. fragilis*, Stretch, from Nevada; *C. constricta*, Stretch, on *Quercus conomensis*; *C. strigosa*, Stretch, from Yosemite Valley; *C. erosa*, Stretch, from Oregon; and *C. thoracica*, Stretch, as feeding upon Willow. The genus, however, seems to be far more numerous represented. In addition to this I have bred one species from the Sierra Nevada Mountains upon *Ceanothus* and wild cherry (*Prunus demissa*); a second species was found to be very abundant in Los An-

* Insect Life, Vol. II, No. 3, p. 74.

† Papilio, Vol. I, No. 5, pp. 63-69.

geles County upon a species of Oak ; a third species was bred in the Santa Cruz Mountains feeding originally upon *Ceanothus thyrsiflorus*, but it was extremely abundant also upon fruit-trees, especially prunes and plums. I also found eggs of one of these moths in Shasta Valley upon a species of wild Currant. Of all the species the most abundant upon fruit-trees was *C. thoracica*, originally feeding upon Willow. This species defoliated most of the trees in Napa and Sonoma Counties last year. On my visit to Sonoma County this month (October), I found numerous old skins still present everywhere upon apple trees. They were either *C. thoracica* or *C. constricta*,—these two larvæ resembling each other somewhat. Fortunately the eggs as well as the larvæ are preyed upon by numerous parasites. Professor Rivers, of Berkeley, informed me that of one egg-mass of *C. constricta* each egg produced a small hymenopterous parasite. I have myself bred something similar from egg-masses on *Ceanothus cordulatus*. The old remedy* will be found best, viz, cut off and burn the egg-clusters during the winter, and collect and burn the nests in spring.

CUT WORMS.

Various Noctuid larvæ are usually numerous and destructive to orchards, vineyards, grain, and vegetables during spring, attacking the young foliage, twigs, and even fruit of trees, while in vineyards they often defoliate large numbers of the vines. As yet I have never been able to obtain any specimens of these larvæ from the injured field for breeding. Dr. Behr, of San Francisco, has shown me one larva that had been received from Santa Cruz, where they injure the vines ; he did not, however, succeed in breeding them and the species is as yet not known. The larvæ bore the closest resemblance to those of *Agrotis messoria* Harris (*cochrani* Riley),† yet many of these Agrotid larvæ resemble each other so closely that their distinction can not be made with any certainty. A similar insect, if not the same, was bred from the eggs. (No. 378k). During September and the first of October, 1887, many of these moths came to sugar at Alameda, and were at the time the most common of all so collected. A number of them were confined in boxes but no eggs could be obtained until the middle of October. The eggs were of a straw-yellow color at first and after ten days changed to a dark grayish color, showing that the embryo had come to maturity. The young larvæ, however, did not come out before the rains set in, December 8, at which date they began to issue and continued to appear into January, 1888. They were kept and fed in a room and attained full growth in about five weeks, pupating at the end of March and issuing as moths one month later. This peculiarity of hibernating either in egg, larva, or pupa state during the dry season has been observed in numerous other insects in California, which are

*Professor Riley's Third Missouri Report, p. 120.

† *Ibid*, pp. 74-76.

dependent upon such plants as are dried up from July until the rains set in, generally October or November. I will give here the history of one of these :

Agrotis crenulata, Smith.—On September 29, 1887, one pair of these moths was found about 10 p. m. *in coitu* on the upper side of a leaf of *Quercus agrifolia* at Alameda. The female began to lay her eggs the following day and continued until October 10, after which she died. On counting it was found that the number of eggs was 1,026. The young larvæ began to issue on October 12. They are, when full grown, very similar to those of *A. clandestina*,* for which they were taken before being bred. Naturally all such larvæ grow very slowly during the winter months, and reach their full growth about March, when they may be found most anywhere amongst grass, grain, or vegetables. Their chief food, however, consists of grasses. From larvæ that entered the ground in breeding cages on March 12, the first moth came out on April 16. In a state of nature it would be about the same probably, allowing for a week's variation either way in the appearance of the moths according to the situation of the chrysalids. The moths are found from April to July, being most abundant during May and June, at least in localities where food is sufficient. In the Santa Cruz Mountains they were observed to appear soon after dark upon the flowers of *Jesculus californicus* (Buckeye), and could be seen in numbers every night until the flowers disappeared ; in other localities, where flowers and natural food are not so abundant, they may retire sooner into their hibernating quarters. During June, 1886, I found them very abundant in a deep, shady cañon in Los Angeles County, amongst leaves, flying up at my approach and settling down a short distance off. On my visit to the same locality one month later not one moth was seen on the wing. But if at this time one searches closer down amongst the dead and damp leaves they will be found in a semi-dormant state. After being exposed a short time they soon fly off to a dark corner and disappear again. In such condition they were observed all last summer in the Santa Cruz Mountains. In open country, distant from woods, they may occasionally be found hidden under or between boards or in old stumps, rubbish, etc. They prefer, however, to hide in the woods amid the dead leaves found there. As in other parts the warm rays of the sun in the spring awaken many of the hibernating insects, so here the first rains in fall will do the same, especially with the Noctuidæ.

NOTES ON THE HABITS OF THE CODLING MOTH AND ITS ENEMIES AND PARASITES IN CALIFORNIA.

During my repeated visits to the Santa Cruz Mountains the past summer some observations were made upon the Codling Moth and its enemies which may be of interest. The moth as a rule is double-brooded in that locality, and no doubt will not differ in its habits to any extent

* Professor Riley's First Missouri Report, p. 79.

throughout California. They may appear somewhat earlier in the valleys. From dates noted in 1887 some of the moths were out on April 22 at Santa Clara, and one larva found then did not produce the moth until May 10. Two days after this they were also observed flying at Alameda. One larva found under bark of pear tree at Los Angeles on July 19, 1886, and evidently of the first brood, did not produce the moth until the end of April the following year. During August, 1887, the moths were abundant at Alameda; on the 2d of the month a cocoon was found about 8 feet from the trunk of the tree, under a fallen apple, from which the larva had issued. The moth from this appeared on the 13th of the same month. Two days later, on a hot and sunny day, while walking through an old apple orchard at 10 p. m., moths started up either from the trunk or lower leaves of nearly every tree and settled down again, generally higher up and on the upper side of leaves exposed to the sun.

Larvæ and chrysalids were found in abundance the same day, and from one of the latter a parasite issued on August 26. This proved to be *Pimpla annulipes*. Up to September 17 moths issued from the chrysalids; one larva that pupated during this month did not, however, produce the moth until December 10. During 1888 the first moth was observed at Alameda as early as March 17, sitting on the upper side of an orange leaf exposed to the sun. But very few of the apple trees were in bloom at this time. Two days later moths began to issue in the house from larvæ collected the previous December. Several issued up to March 28. The present season the moths were not observed in any numbers before May 25 in the Santa Cruz Mountains. The fruit at this time was about 1 inch in diameter. From this date on until the end of June there could be seen at dusk from 25 to 50 on each tree. The place is situated on the east side of the hills. About a half hour after the sun disappeared behind the mountains, and while it was yet visible for nearly that length of time on the opposite hills, the moths began to appear, flying with quick movements around the trees, chiefly near the top, and settling down again upon the leaves or fruit from time to time. This was kept up until towards dark when they became less numerous. During this time both sexes may be readily collected with a long butterfly-net. I have taken many near the ground on the lower leaves and often distant from fruit trees. By their peculiar flight they are easily distinguished from any other species of moths.

About the middle of August, at which time some of the fruit had already been taken off, the second brood made its appearance, yet at this time many larvæ could still be found within the infested fruit, and from material collected then and taken to Alameda, moths came out in numbers until September 12. I was informed that Bartlett pears taken from the trees when the second brood had made its appearance were all sound, not one in twenty being wormy. On examination, however, I found the opposite to be the case. About one pear in twenty only was

found without any eggs or traces of young larvæ of *Carpocapsa*, the second brood having already begun its destructive work. From these few notes it is evident that with a little care early fruit can be kept almost free from the attacks of the worms, while with later sorts this becomes more difficult, and such fruit generally is rendered useless by the attacks of the second brood, and is fed to pigs.

Enemies.—Enemies of the Codling Moth appear to be quite abundant in California already. I have indeed been surprised in finding minute Chalcids infesting the eggs.* These are not numerous, and had not been observed on eggs of the first brood, yet they may have been present. In fourteen boxes of Bartlett pears examined on August 20 and 21, about seventy parasitized eggs were found, and about an equal number from which the parasites had issued; no doubt some were overlooked. But few of the pears showed traces of worms of the first brood, yet nearly all contained eggs of the second brood and very often more than one. As many as eleven eggs were found upon a single pear. One was found on the stem, six on the pear surrounding the stem, two on the upper half and the other two near the calyx. Of these, two contained parasites, one of which had issued, two were still fresh, and the rest had hatched. I should note here that the pears had been taken off three days previously. In other pears with less eggs, as many as three and even four young larvæ were found. The eggs found upon pears were most numerous near the stem, the others almost invariably on the upper surface of fruit, and but very few on the lower part or calyx. It was also observed that the young larvæ very rarely enter the fruit where an egg is deposited, but generally somewhat lower down, and in many instances instead of going to the center they leave their first mine after a few days and enter at the open calyx. On apples it appears they will oftener enter the fruit from the sides.

Many of the eggs of the first brood were destroyed by some enemy, what I could not learn. They had a brownish and shrunken appearance, and it is probable that they were destroyed by the *Chrysopa* larvæ, which were present in numbers upon the trees at the time. With the exception of these and the *Coccinellid* larvæ no other insects were observed in numbers likely to destroy the eggs. This was not observed to be the case with eggs of the second brood, at which time the predaceous larvæ mentioned had disappeared. The other three parasites bred during the summer are all from the chrysalids. The most efficient destroyer of *Carpocapsa*, however, is a small bat which is always in search of the moths, appearing somewhat later than the latter, but keeping up its chase until dark, when apparently the moths cease their flight and the bats go off in search of other food. Every night during June as many as six of these bats were to be seen flying around an isolated apple tree upon which there were a large number of the moths, not only taking the *Carpocapsa* on the wing, but very often darting at a

* This parasite is a species of the genus *Trichogramma*.—C. V. R.

leaf to get the resting moth. Of not less value is the larva of a Neuropterous insect, a *Raphidia*, which is present in numbers. Its long and flat structure together with its activeness enables it to hunt up any larva that may be present under bark or in crevices of the tree.

Not only is the larva devoured but the chrysalis likewise, and without doubt often the mature moth. It was indeed very hard work to find any larvæ or pupæ of *Carpocapsa* upon trees where the larvæ of *Raphidia* were present, and the latter occurred upon nearly every tree. As a rule, not more two or three could be found upon one tree by breaking off all the loose bark and examining the crevices, and often none at all. These larvæ are always on the lookout for food, crawling up and down the trees, but being chiefly concealed by the bark. Away from the trunk of the tree, however, more larvæ are found. An old and partly decayed stump or piece of wood lying anywhere near an infested tree will always be full of them; and, as has before been pointed out, many of the larvæ of the first brood, at least, spin up in the dry ground. I will again refer to the Dermestid larvæ mentioned before, not only as destroying the pupa of *Carpocapsa* but likewise the larva, during the summer season at least. Many apparently sound cocoons when cut open will be shown to contain larvæ and skins of some of these beetles. The contents have been devoured while there is no visible hole in the cocoon, showing that the larva had entered while young. This alone would not be sufficient evidence, but I have also found small larvæ of *Trogoderma tarsale* within the cocoons, and with the larvæ, dead and living, of *Carpocapsa*.

In two instances the half dead *Carpocapsa* larvæ showed small holes in their sides which had partly healed up. These no doubt were made by the Dermestid larvæ, which as a rule feed upon dry insect remains, and only kill living larvæ gradually by feeding upon the skin only at first. In many cases they were found with larvæ that had recently died, having already undergone several molts within the cocoons of the last larvæ. They are very abundant, especially around Alameda, as many as four or five large larvæ being often found within the cocoon and feeding upon the dead pupa of *Leucaretia acraea*. In almost any old egg-mass of *Orgyia* they are found. Whether they will feed upon the eggs or not I have as yet no evidence. Insect collections are not as much troubled by these beetles in California, especially in the valleys, as in the Eastern States. I have often observed them, however, to infest collections in the mountainous districts. A coleopterous (Clerid?) larva was recently found in the Sonoma Valley feeding upon *Carpocapsa*, but has not yet been bred. Numerous Carabid beetles were always found at the base of trees awaiting their chance to get a bite at the *Carpocapsa* larvæ. The most numerous of these were *Pterostichus californicus* Dej. and *Calathus ruficollis* Dej. A bright light with a white sheet below and behind was kept burning near the orchard in the Santa Cruz Mountains while the moths were abundant. One female

only was caught in this about one hour after dusk. Never before during my fourteen years of collecting moths with lights, sweeps, etc., have I, within my memory, collected a single *Carpocapsa*.

THE HESSIAN FLY.

(*Cecidomyia destructor*.)

This insect has been quite abundant and destructive to grain in the central part of the State during the season. A Mt. Eden correspondent wrote to the *Oakland Engineer*, May 2, as follows :

The Hessian fly has done irreparable damage to the grain in this vicinity. There has been hardly a field that has not been attacked. The prospect for a large barley crop is very good. The wheat crop will be a comparative failure. What is left from the Hessian fly is being destroyed by the rust.

Personally, until this spring, I have had no opportunity of making any observations upon this insect. On May 26, while in the Santa Cruz Mountains, it was noticed that some of the barley had fallen to the ground. On examination, puparia of the Hessian fly were found in places where the straw was fallen. The insect was found at the time in all stages from young larvæ to puparia, and some of the latter had recently hatched. From puparia collected at the time, flies made their appearance until the beginning of July. Other puparia collected about July 1 have not hatched up to date, and the insects are still in the larval state within the puparia. A few specimens of parasites (*Merisus destructor*) were bred from these, and from the same straws several specimens of an *Isosoma*.

During September, 1887, I found puparia, which I took to be those of the Hessian fly, on two species of grasses near here. These were forwarded to Washington, where they arrived in good condition, as stated in letter of October 3d, and the grasses were determined as *Elymus americanus* and *Agrostis* sp. Again during the summer I found the puparia upon several species of grasses in the Santa Cruz Mountains. I shall be prepared next season to give a list of grasses upon which the Hessian fly is found, and also more accurate notes as to the habits of this insect, which, as it would appear, is a very old resident of this coast.

JOINT-WORMS.

(*Isosoma* sp.)

These insects have been abundant and destructive in most wheat-growing sections, and they will continue to be numerous until stricter measures are employed for burning the straw and stubble.

LOCUSTS.

These did not appear in any large numbers except in the northern part of the State and, from some accounts, in Oregon. On my visit to Shasta Valley, Siskiyou County, at the end of July, locusts were no-

ticed in large numbers north of Edgewood and throughout that valley. At Montague I was informed that, on account of the unusually dry season and the crickets and grasshoppers, the crop had been an entire failure in that district. Around this latter place no vegetation except a few sage-bushes were visible. Along the creeks, where a little grass and vegetation was still growing, the locusts were swarming. *Dissosteira oblitterata* Thos. was abundant throughout the valley. Even in places where for a half a mile not a shrub or any dry plant was visible they appeared to be happy, but were seen abundantly along water-courses and places still affording some food. *Melanoplus cinereus* Scudd. was more numerously represented in places where food was still to be had, even if dry. But few specimens of *M. femur-rubrum* DeGeer were seen, while *M. packardii* Scudd. was the most abundant of all, feeding upon grasses along streams, and in all the meadows, where it outnumbered all the other species put together. Here they were often observed, always the female, caught in the web of a large spider, which feeds upon them.

M. devastator Scudd. was not met with throughout the summer, while *Camnula pellucida* Scudd. was only seen occasionally in the places visited. Another numerous species in the Shasta Valley was *Hesperotettix pacificus* Bruner, but this was found feeding upon sage-bushes only. About eight other species of locusts were found at Montague, of which *Dissosteira carolina* Linn., *Trimerotropis fallax* Sauss., *Conozora wal-lula* Scudd., and *Stenobothrus coloradus* Thos., were the most abundant. Two species of large crickets have been very numerous at Montague also joining in the destructive work—*Anabrus simplex* (?) Hald., and the other a species of *Steiroxis*. The common cricket, *Gryllus luctuosus* Serv., was abundant in the central part of the State, often coming in large numbers into cities and into houses.

REPORT ON NEBRASKA INSECTS.

By LAWRENCE BRUNER, *Special Agent.*

LETTER OF TRANSMITTAL.

LINCOLN, NEBR., Nov. 20, 1889.

SIR: In presenting a report on the insect injuries in Nebraska for the past spring and summer, it is not my intention to mention all the species that have been observed in the act of depredating. Neither do I expect to enter upon a discussion of their life histories. To do this would require altogether too much time and occupy considerable more space than could be allotted to such insects as have been repeatedly described in your various reports upon injurious insects. Suffice it, then, for me to mention briefly a few of the species that most attracted my attention, either by their appearance in unusual numbers, their more than ordinary injuries, or by their peculiar mode of attack.

During the year most of the well-known species that are always present in more or less injurious numbers, were noticed at their regular seasons of appearance. These were, of course, expected; and, unless either very numerous or scarce, were but little noticed. Aside from these, few new or original observations were made during the active season; but several new enemies were observed to act in connection with old and well-known forms.

Since my last report, some time has been devoted to the *Acerididae* of North America, in the continuance of our work upon that family of the order Orthoptera. The latter work was chiefly in the line of looking up the matter of distribution, the characterizing of new material, and the massing of such additional species as could conveniently be obtained without expense to the Department. Some little was also done in this connection in the study of several minor locust outbreaks in different parts of the country, as, for example, in Utah, Minnesota, and the White Mountain district of the New England States. Of these different outbreaks you already have been advised; Mr. Otto Lugger, of the Minnesota Experiment Station, reporting on that of his State; Mr. C. L. Marlatt, that of New Hampshire, and myself upon that of Utah.

LAWRENCE BRUNER.

Prof. C. V. RILEY,
U. S. Entomologist.

FALSE CHINCH BUGS.

Early in the year, during the month of May, two or three species of small hemipterous insects began to gather upon several farms just outside the city limits of Lincoln. These appeared in much larger numbers than is usual for the insects under consideration; and from their size,

order, and general appearance were mistaken for the chinch-bug (*Micropus leucopterus*) by many of the residents. This mistaken identity in the case of these insects was the occasion for much apprehension, as it well might have been had that insect put in its appearance in such great numbers so early in the year. These "false chinch-bugs," for such they were, began work by attacking the weeds and everything else that was green growing in the fields which were infested. The weeds soon disappeared and the insects transferred their attention to apple, catalpa, mulberry, and other small trees. But by far the greatest injury was done to grape-vines. They were all small, and were kept divested of every vestige of new growth for a time, and looked as if the vines never would be green.

The three insects which united in these demonstrations were the following: the False Chinch-bug (*Nysius angustatus*), the Purslane bug (*Geocoris bullata*), and a species that is quite common here in the West among various rank-growing herbs and weed-like plants, and is known to the entomologist as *Trapezonotus nebulosus*.

The first named of these was by far the most numerous, and if working singly would have occasioned nearly the same amount of damage as did the three. The second and the last named were present in nearly equal numbers, perhaps the last being the commoner of the two. All three species gathered upon the main stems and larger branches of the trees and even in clusters upon the scattered remnants of the last year's vegetation. They were pretty well scattered over the fields, but appeared to be most numerous upon some hill-slopes where they had been attracted during early spring and late fall by the warm sunshine. These clusters of bugs were composed of individuals of all ages and sizes, ranging from those apparently but a few days old to those fully matured and winged. An investigation soon disclosed the reason for their abundance in this particular locality. Last year these fields had been permitted to grow up in weeds after the spring cultivation. These weeds, purslane, tickle-grass, stink-grass, and tumble-weeds, made a splendid retreat for the bugs to gather, feed, and breed in, and afterwards to winter in. The present spring being dry weeds and grasses were slow in starting. Not so with the bugs. Eggs were laid at the usual time, these hatched and the little bugs soon exhausted what green vegetation there was for them to feed upon, and which was very slow in appearing on account of lack of the necessary amount of moisture. The trees and vines being deeper rooted sent out their buds and green leaves. These attracted the hungry hordes of bugs, and were at once attacked in bud, leaf, and stem, the bugs inserting their beaks and extracting the sap. The consequence was the injury spoken of above.

As a remedy against the destruction of the grape-vines I suggested covering the vines, which were small ones, with dirt for a week or ten days until weeds had an opportunity to grow, after which time there would no longer be danger, and as a preventive for the future to keep down the weeds in late summer, especially when the season is a dry one.

In habit these three bugs resemble the Chinch Bug to a considerable degree, only that they are earlier in their egg-laying, and that their food-plants are weeds and other herbaceous plants, rather than grasses. They also move about on the wing in a similar manner to that of the *Micropus leucopterus*. Last spring, on one day in particular, the air was full of these and other small hemipterous insects. At just what date this flight occurred I do not remember now, but know it was during the month of May.

The three species referred to above in connection with the injuries recorded, all occur upon ground that has been neglected and allowed to grow up to purslane and *Amaranthus*. The two latter named are also occasionally found about smart-weed (*Polygonum*) during late summer and fall, while the first mentioned is also inclined to be partial to "stink" grass at times.

CUT-WORMS.

Scarcely a year passes without a report of damages from cut-worms in various parts of the country. Here in Nebraska quite a large number of the night-flying moths belonging to the genera *Agrotis*, *Hadena*, *Mamestra*, etc., are often the cause of much worry and not infrequently the loss of much time and money to the farmer and gardener.

At about the same time that the bugs mentioned above were the most plentiful and doing their injury to trees, vines, etc., the reports of cut-worm depredations began coming in to the station from various districts within and without the city limits. These reports included injuries to both garden and field crops, and from the fact that they were received from widely separated localities, the pest was quite general over the eastern part of the State. Specimens of at least a half dozen distinct species of the worms were received by me, along with the statement that they were the authors of the injury. Among these I recognized *Agrotis annexa*, *A. suffusa*, *A. messoria*, *A. saucia*, and *A. clandestina*.

So abundant were several species of these worms that they literally cultivated the ground at places where they burrowed during day-time. Nor did the worms content themselves with feeding upon cultivated plants alone, but also, in many instances, kept down the weeds. Here in the city of Lincoln, upon a vacant square that had been used by the boys as a base-ball ground, and where the ordinary "pepper-grass" was growing in profusion, the *Agrotis annexa* finally succeeded in clearing the ground of this weed. So voracious did the worms become before maturity that the pepper-grass was even cut off and the stems drawn into their retreats in the ground, where they might be devoured during day-time. On cloudy days the worms even ventured forth to feed openly by daylight, scurrying back into their holes when the sun came out for a moment. In the hard trampled ground their holes were smooth-cut and presented a very interesting sight indeed when the occupants issued forth and quickly returned upon the least disturbance, like

some animal of greater intelligence. The larva of this particular species of *Agrotis* is exceedingly active, reminding one not a little of some of the chipmunks among the rodents.

A second species that much interested me is the larva of an *Agrotis* sp. that was exceedingly numerous upon the college farm and adjoining tracts to the eastward of the city. This latter worm worked on various plants in the garden, but on the farm showed decided taste for clover. Here it literally "lived in clover" in large numbers. The different kinds of clover growing in the experimental plats suffered much. It was here that one of the instances above cited of cut-worms cultivating the soil occurred.

The remedies used against these different cut-worms varied somewhat in their character; but they were chiefly hand picked or crushed. Many of the worms also perished from the attacks of predaceous beetles either in the larval or imago stages, and of parasites of one or another sort. A few of them also from diseases that resulted from the presence of fungi or bacteria. The parasitized worms were the result of the eggs laid by *Tachina* flies in most cases. The *A. annexa* larvæ suffered most in this respect, on account of their habit of coming out to feed during the day-time.

ARMY-WORM.

As the State grows older in its settlement the reports of Army-worm depredations become more frequent year by year. Last year I reported the appearance and damage by this insect in the extreme northwestern part of Nebraska, as well as in portions of southwestern Dakota. During the present year several localities in northeastern Nebraska were overrun to a limited extent by the larvæ of *Leucania unipuncta*. None of these areas infested were of very great extent, nor was the injury committed complete in any of the cases coming to my notice. Millet and oat fields were the chief sufferers.

A small black fly was bred from larvæ received from Mr. J. M. Seymore, of Pender, Thurston County. This fly has frequently been observed by me at various points in northern Nebraska, where I have taken it in my net when sweeping for other insects on the prairie. It must be a regular enemy of *Leucania unipuncta*, and perhaps also of other allied species, since it is by no means an uncommon insect every year. Others of the flesh-flies (*Tachinidae*) also act as guards against this insect's rapid increase, as can readily be seen from the fact that many of the larvæ taken have the eggs of these flies attached to their bodies.

Visiting again this year the region last year reported to you as having the insect present in injurious numbers I was pleased to find that the *Leucania* had not appeared in numbers sufficiently great to attract the attention of those persons who lost crops by their depredations last year. In fact I am pretty confident in asserting that there are no grounds for fearing this insect next year, in the State of Nebraska at least.

THE GREEN-LINED MAPLE-WORM.

For the third time, now, many of our soft-maple trees in the city of Lincoln have been entirely defoliated by the larvæ of *Anisota rubicunda*. This insect has been steadily increasing for the past three years, and if it does not soon die off by some epidemic disease or is killed by parasites the growing of this tree will be very difficult. This state of affairs is due entirely to the negligence of our citizens in general, who, it appears, can not be induced to spend the little time necessary for the destruction of insect pests that attack their shade trees, garden and farm produce, and flowering plants. The entomologist can not kill all the insects, good and bad, in the country; neither are his words of advice heeded in the least when he tells how each insect enemy is to be gotten rid of by means of the least labor and expense to those who should be most interested.

THE BLUE-GRASS VEEVIL.

For the past two years *Sphenophorus parvulus* Gyll. has been increasing quite rapidly in numbers, so that now it has come to be one of our commonest beetles in the city of Lincoln, at least, if not elsewhere. From the fact of its frequenting sidewalks, or being concealed under boards, sticks, and stones that were left lying about on the University campus, and on lawns elsewhere in the city, I began an investigation as to its probable breeding place. This study has led to the discovery of its feeding upon the roots of the common blue-grass (*Poa pratensis*). So plentiful has the insect become in some lawns that the sod has been entirely killed over large patches.

The larva is a short, thick, whitish grub, like those of other species of the genus, and measures from 4 to 5 millimeters in length when fully matured. The beetles appear twice a year, *i. e.*, in the spring and early fall, the insect probably being double-brooded. Some of the beetles may come out in fall, while the remainder may lie over winter as pupæ. The fully matured larvæ were found early in June, while others were observed last October. Damp and well-watered lawns appear to be infested fully as badly, if not worse, than those that are dryer, although they do not show the injury nearly so quickly in the former as in the latter case.

While looking for larvæ during the latter part of last May, numerous specimens of a small white "hair-worm" *Mermis* or *Gordius*, or some allied genus, were found scattered through the soil. These were only obtained at very damp places under trees on the University campus, and as a rule were tightly coiled. Whether these would have or had been in any way connected with the *Sphenophorus* larvæ, I do not know, as I am not sufficiently well acquainted with these forms nor with their life-histories. Various ground-beetles (*Carabidæ*) and their larvæ certainly do devour the larvæ of *Sphenophorus*, since the former were also quite common in the localities where the latter abounded. No experi-

ments were carried on with a view to finding a remedy against the injuries of this weevil.

THE CORN ROOT-WORM.

(*Diabrotica longicornis*.)

This insect is becoming alarmingly common in the counties of eastern Nebraska and those of western Iowa; and, judging from the general food habits which the imago appears to be developing, it may soon become a much more dangerous pest than we at present imagine. During the past summer and fall the beetle has been almost omnipresent, so common was it in the vicinity of Lincoln. It was found upon a large variety of plants belonging to different orders. It was beaten from trees such as maple, box-elder, elm, ash, willow, cotton-wood, and oak. I found it rather common among the grasses and obtained it in plenty in gardens where it was feeding upon the leaves of radishes and turnips, in several instances completely riddling these latter with holes. As late as September 28, the beetle was still quite active during daytime, and quickly took to flight upon being disturbed. In August it was observed to be nocturnal in its movements, as was to be seen by the large numbers of the beetles that were attracted to and gathered about the electric lights. On the morning of the 15th, 260 specimens of the beetle were taken from the globe of a single arc light that hangs in front of University Hall upon the campus of the State University. These had all been attracted to and caught in the globe in a single night. Whether or not these came from the farms in the surrounding country I can not say. Might not the species work in the roots (for the larva is a root-borer) of some other plant or plants beside corn? At any rate it is my present intention to look into the life-history of the Corn Root-worm a little more closely during next season. It is getting to be by far too common an insect in these parts for us to be running chances in dealing with it. Rotation of crops may or may not always prove to be a remedy against its depredations.

INSECTS DETRIMENTAL TO THE GROWTH OF YOUNG TREES ON "TREE CLAIMS" IN NEBRASKA AND OTHER PORTIONS OF THE WEST.

For several years now I have been interested in the study of the insect pests that render the growing of young trees upon claims entered under the "timber-culture act" quite a difficult and tedious matter. This interest in the subject had its origin partly in personal experience and partly from the numerous complaints of others who have experienced great difficulty in securing a sufficient growth in their young timber within the limitations for making final proof. Not infrequently has it been the misfortune for those striving to gain titles to Government lands under this act to have their trees completely defoliated for several years in succession. Nor have these injuries been confined to any single kind of tree. Since commencing the study of the subject I have either

seen or heard of all of the following species suffering alike from this cause: Ash, Box Elder, Soft Maple, Cottonwood, and Willow. The honey locust, too, has been subject to defoliation by insect enemies when growing as hedges upon the uplands of the semi-arid regions west of the 97th meridian. Some of these trees thus attacked were killed outright, while others were set back a year or more by each defoliation.

Several different lines of investigation have been followed in the study of this subject, viz, the comparative freedom from insect attack of the various kinds of trees; the influence of topography upon the growth of each kind of tree, as well as upon the increase and development of the insect life thriving upon the tree; also the comparative abundance or absence of birds and parasitic insects in the different regions, and what relation these bear to insect depredations. Of course, when fully carried out in the several lines indicated above, the investigation of such a subject can not fail to be quite extensive and result in some good to the parties most concerned. For the present paper, however, only a few of the most important of these insect enemies will be mentioned, and then only cursorily. Of these there are about thirty species belonging to the orders Coleoptera, Hymenoptera, Lepidoptera, Orthoptera, and Hemiptera. Most of these insects that I wish to call attention to are quite general in their distribution, and therefore as well known to you as they are to those living in the "tree-claim" region. My report will then simply consist of a statement as to their abundance, distribution, and the amount of injury done by each species. To do this the following table will best express my wishes and at the same time be least cumbersome. All of the species therein mentioned have been either observed by myself or were reported by others as occurring in injurious numbers during different seasons upon tree-claims located in Nebraska, Kansas, and Dakota.

Insect.	Tree.	Insect.	Tree.
HYMENOPTERA.		<i>Cressonia juglandis</i> A. & S.	Walnut.
<i>Cimbex americana</i> Leach	Willows.	<i>Clisiocampa americana</i> Harr.	Most kinds.
<i>Monophadnus barda</i> Say	Ash.	<i>Clisiocampa sylvatica</i> Harr.	Do.
COLEOPTERA.		<i>Datana angustii</i> G. & R.	Black Walnut.
<i>Lina scripta</i> Fab	Willow and Cottonwood.	<i>Anisota rubicunda</i> Fab	Soft Maple.
<i>Chrysomela</i> sp	Do.	<i>Hyphantria cunea</i> Drury	All kinds.
<i>Disonychia pennsylvanica</i> Ill.	Willow.	<i>Apatela populi</i> Riley	On Cottonwood.
<i>Chrysobothris femorata</i> Fab.	Box Elder and Maple.	Do	Willow.
<i>Lachnosterna</i> (several species).	All kinds.	Do	Maple, Box Elder.
<i>Epicaula cinerea</i> Forst	Honey Locust, Coffee Bean.	<i>Tortricid</i> (—)	Honey Locust.
LEPIDOPTERA.		<i>Sphinx</i>	Ash.
<i>Papilio turnus</i> Linn	Ash.	Do	Elm.
<i>Vanessa antiopa</i> Linn	Willow, Elm.	<i>Tortricid</i> (—)	Boring twigs of Hackberry, Box Elder.
<i>Platysamia cecropia</i> Linn	Maple, Willow, Box Elder, etc.	ORTHOPTERA.	
<i>Telega polyphemus</i> Cramer	Maple, Elm, Box Elder, etc.	<i>Ecanthus niveus</i> Serv	Stems of various trees.
<i>Triptogon modesta</i> A. & S.	Willow, Cottonwood.	<i>Ecanthus latipennis</i> Riley.	Stems not so common.
		<i>Melanoplus spretus</i> Thos	Foliage of all when numerous.
		<i>Melanoplus femur-rubrum</i> DeGeer.	
		<i>Melanoplus differentialis</i> Thos.	

Almost all of the above named insects are sufficiently numerous at times, when working alone, to kill or at least to greatly retard the growth of the tree or trees upon which they feed. Of course, they do not all occur at once in any given locality in such overwhelming numbers, nor are the injuries the same every year; but quite frequently two or more of the species are found feeding in company upon the same tree in numbers sufficiently great to do harm. In addition to the species named above there are a great many others that are also known to attack and injure the trees growing upon tree-claims; but these latter have not yet made their presence so strongly felt as to force us to place them on the list of insect pests in connection with tree-claim culture. For a description and life history of many of these the reader is referred to Bulletin No. 7 of the United States Entomological Commission, entitled "*Insects Injurious to Forest and Shade Trees.*"

Causes for these Insect Injuries.—There is a cause for everything, so in the present instance we must look for one or a combination of causes that work together in producing the undue increase of insect life upon the prairies when new varieties of plants are introduced. A very superficial survey of the ground will quickly reveal to us some of these causes.

In the first place, there are always a few dwarfed trees of most of the kinds that are usually planted upon claims. These trees are scattered along the water courses, in ravines and gulches, and a few other localities that are protected from the fires which have annually swept over the broad prairies for generations. These few trees furnish food for small colonies of the various species of insects that we have named. There are always enough of them to very quickly stock a claim close by upon which small trees are planted that are to their taste. Then, too, all of these injurious insects are of a hardy nature, used to a precarious life, and are strong fliers capable of making comparatively long journeys in search of food for themselves and their progeny. They are, in fact, the nomads of the insect world, capable of withstanding the vicissitudes belonging to a life upon the vast prairies where the more delicate parasitic forms could not live or even find shelter. Then, too, their requirements for quarters in which to pass the long, cold winter months are less complex than are those of the species that come later on.

In the second place, the country being destitute of groves of timber among the branches of which insectivorous birds can find shelter and build their nests most of these insect destroyers are absent. Of course, the absence of so great a factor as are these birds in the ridding a country of its insect pests soon becomes apparent in the increase of the latter and of the accompanying injury done by them. The absence of groves, too, not only keeps away the feathered tribe, but also prevents many of the more delicate parasitic and a large number of the predaceous insects from becoming established in the region. The majority of these latter forms of insects, as before stated, are such as require

sheltered retreats in which to lurk or to get away from the hot dry summers and the long cold winters.

In the third place, the comparative aridity of the region where these claims are located renders the growth of them somewhat slower than where the precipitation is more bountiful. This slowness of growth, while it is an advantage in one respect, aids the insect foes to a considerable extent in their work of destruction. A rank and rapid growth places a tree out of danger from external enemies much more quickly than will a slow growth. At the same time in rank growth a much greater amount of food is furnished for the same number of insects, and as a consequence less injury to the tree results than would were the growth slower.

A fourth cause for the rapid increase among these different insects in new regions is the absence of such fungoid diseases as are known to attack and kill various of these pests. After awhile, however, the germs of these diseases become diffused through the soil, vegetable débris, and about the encumbering growths, buildings, etc. These germs are carried around by the elements and other agencies, and in time some of them find lodgment within the bodies of such insects as are susceptible to their growth. The result is disease and death.

Comparative Freedom of different Trees from the Attacks of Insect Pests.—Up to the present writing I have not sufficiently investigated this portion of the subject to be entirely positive in my assertions as to the kind or kinds of trees most nearly exempt from the attacks of insect foes in different regions. None of them are entirely free; but that there are trees which suffer less than others in this respect is a well-known fact, and can be seen at any time where several kinds are growing side by side or in the same grove. Again, a particular kind of tree might be troubled in a given locality, while in another it would be comparatively free. Some trees also suffer while small, and others are usually injured after they have gained considerable growth and age. These variations with regard to insect attacks among different trees, and of the same kind at different ages, are governed by laws the explanation of which would require much more time and space than I have at my command. By looking over the list of insects mentioned above it will be seen that no reference is made of any species injuring either the Catalpa or Russian Mulberry. The Ash is affected by three, each of which at times strips it of foliage while young; the Box Elder by two or three; the Willow by a dozen or more; the Cottonwood by four or five; the Soft-Maple by several; the Elm a couple; the Honey Locust two, etc.

In treating this subject only such insects have been mentioned as have been ascertained to attack the various trees during their first few years of growth, and before they have attained any great size. Other species of insects injure these trees later on; but, as a rule, these latter

are less destructive to them save in a few instances. Only a very few borers work in healthy young trees in this region.

Remedies tried and suggested.—Only a few remedies have been generally tried against these pests in the region of tree claims, and most of these were confined to the various methods of “hand-picking” and crushing. Spraying and dusting with poisons and kerosene emulsions, or the use of road dust, ashes, air-slaked lime, etc., have been reported only in a very few instances. Any or all of these methods of warfare when properly carried on and used intelligently, in accordance with the habits of the insect that is being fought, will repay one for the time thus spent.

LOCUSTS OR GRASSHOPPERS.

Aside from several local outbreaks there has been no special damage done during the year by locusts within the United States. Of course, you are already acquainted with the particulars in connection with the local injuries, of which the chief are the following: The Rocky Mountain or migratory species at Nephi City, Utah; the same in Otter Tail County, Minnesota; and the lesser and red-thighed species in the mountain districts of the New England States. The Utah outbreak was partly investigated by me at the time (May) of its occurrence, through correspondence with the Hon. James B. Darton, of Nephi City. That gentleman supplied me with specimens at different times from which the insects under consideration were determined. The conclusions at which I then arrived were reported to Mr. Howard in your absence. If I remember rightly, both the Rocky Mountain (*Melanoplus spretus*) and the California locust (*Camnula pellucida*) were found among the material received from Mr. Darton. The Otter Tail outbreak has been very carefully written up by Mr. Otto Lugger, of the Minnesota Experiment Station; while Mr. C. L. Marlatt, of the Entomological Division, has reported on the New England outbreak.

While it is not my intention to devote much time to the subject of locust abundance and injuries, I do wish to say a few words concerning the fungoid disease known as *Entomophthora calopteni* of Bessey. During the present summer this disease has been unusually abundant in and around the city of Lincoln, Nebr. Several species of our native locusts were attacked by it; but the large yellow one, known as the *Melanoplus differentialis* Thomas, was destroyed by the thousands. Whether the fungus in question was more plentiful than usual, and did its work of extermination more effectually than during previous summers; or, whether it was on account of my being surrounded by a number of students in botany, and located next door to the botanical laboratory, that attracted my attention to these, I do not know. The impression is, however, that the former is the true explanation. On the University campus alone, where *differentialis* hatched quite plentifully and began doing considerable injury to various small trees and

shrubs, there must have been several thousands of the hoppers destroyed by the disease. Soon after the locusts became fledged some of them were observed to die after first showing signs of disease. After the disease first became apparent among the locusts, it spread, or at least appeared in other portions of the city, the number of dead and dying locusts increasing daily. So fatal did the disease finally become upon the University campus that but few of the *differentialis* escaped to deposit eggs. I know that three or four of the botanical students each collected the dead locusts by the chalk-box full to use as specimens in their line of work, and for exchange, while I gathered many of them myself. During the latter half of August, and early in September, at almost any time one might have secured from fifty to a hundred or more specimens of the dead locusts in a few moments, by simply going outside of the science hall a few yards.

So rapid was the final action of the *Entomophthora* (or *Empusa*, as it has more recently been called) that not infrequently the locusts were found still in copulation, one or the other of the sex being dead. When they were found in this condition, the female, though not always, was the first to succumb. This would not, however, prove anything as to the comparative fatality of the disease as far as the different sexes are concerned. There are other matters to be taken into consideration before we can come to a definite solution of comparative immunity from attacks upon the different sexes of an insect by a disease like the present.

Just how long a time is required for the full development of the fungus after an insect is first attacked I am not prepared to state; neither can I give an account of the various stages through which the fungus passes during this development from the original spore to the stage where such spores are reproduced. Nor am I posted as to all symptoms present during the different stages of the disease occasioned by the fungus within the tissues of a living locust. All that I know is, that shortly before death the stricken hopper climbs up some stick, weed, or blade of grass, to which it clings frantically with its anterior and middle pairs of legs. When found dead these always have their head uppermost.

Whether or not invariably fatal I can not say; and imagine that to ascertain this would be no easy task. I am also quite ignorant in reference to its capability of being artificially spread, since I have had no opportunity to experiment in that direction. Besides, the disease does not appear to be common to all species of locusts alike; or if it is, we do not know it. The subject will bear a much more careful study than has thus far been devoted to it. From an economic standpoint there is still a great deal to be learned concerning insect-attacking fungi, as a few recent experiments in this line clearly demonstrate.

Before leaving the subject of this locust-destroying fungus I wish to add the following notes, prepared for the present paper at my request

by Prof. C. E. Bessey. They will show the most recent views of botanists as to the systematic position of the plant in question :

Entomophthora calopteni Bessey.—The original description of this species appeared in the American Naturalist for December, 1883 (page 1280). It is reproduced here verbatim :

“I. *Empusa* stage, not seen.

“II. *Tarichium* stage : Oospores globular, or from pressure somewhat irregular in outline, colorless, 36 to 39 μ . in diameter; walls thick (4 μ .), colorless, smooth; protoplasm granular, after as if composed of many small cells, often with a large round vacuole. Occurring as a clay-colored mass in the body cavity and femora of *Caloptenus differentialis*.

“Ames, Iowa, August and September, 1883.”

Specimens of this fungus collected in Wisconsin by Trelease and Seymour were distributed under the name given above by Ellis and Everhart in North American Fungi, No. 1801. In April, 1888, Mr. Roland Thaxter published, in the Memoirs of the Boston Society of Natural History, an important paper on The Entomophthoræ of the United States, in which he revises the species of the group, and adopts the older generic name *Empusa*, first proposed by Cohn in 1855, in preference to *Entomophthora* proposed by Fresenius in 1856. Moreover, Mr. Thaxter concludes that the fungus described above is identical with one described as *Entomophthora grylli*, by Fresenius, in 1856. Specimens of this species were distributed in 1885 by Dr. Farlow, in Ellis' North American Fungi, No. 1401. Our species thus appeared in Mr. Thaxter's paper under the name of *Empusa grylli* (Fres.) Nowakowski.

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DIVISION OF ENTOMOLOGY.
BULLETIN No. 23.

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UNDER THE DIRECTION OF THE ENTOMOLOGIST.

(PUBLISHED BY THE AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 3, 1891.

SIR: I have the honor to submit for publication Bulletin No. 23 of this Division. It comprises the reports of the field agents of the Division for the past year (1890), a summary of which has been included in your annual report.

Respectfully,

C. V. RILEY,
Entomologist.

HON. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The reports of the six permanent field agents of the Division are included in this bulletin. They are printed this year in full, but it should be understood that they are little more than summaries of the work in general performed by each one. Special reports upon specific subjects have from time to time been sent in by special direction, and these have been published in *INSECT LIFE*.

Mr. Lawrence Bruner, who last year reported upon the insects injurious to young trees on tree claims, has the present season devoted much of his attention to insects affecting, or liable to affect, the Sugar beet, a crop of growing importance in the State in which he is located. Although but one season's collecting has been done, some 64 species have been observed to prey upon this crop. As has been shown, nearly all of these can be readily kept in subjection by the use of the kerosene emulsion or the arsenites.

Mr. D. W. Coquillett's report is mainly devoted to methods and apparatus for the destruction of scale insects by means of fumigation. The experiments were aimed at the Red Scale, which is one of the most difficult to treat with washes. He describes the simplified tents, the rigging which enables them to be used rapidly, and shows the advantage of excluding the actinic rays of the light. Judging from recent California newspapers the use of this method of fighting scale-insects is rapidly increasing and the comparatively expensive apparatus is already owned by a large number of fruit-growers. This improved method is the legitimate outgrowth of experiments which we instituted at Los Angeles in 1887, and possesses the advantage over spraying that it can hardly be done in a slovenly manner. If used at all its effects are nearly complete.

Mr. Albert Koebele, while reporting upon a number of interesting fruit pests, notably the Tent Caterpillars of the Pacific slope, and a Noctuid larva which destroys the buds of certain fruit trees, devotes most of his report to the description of certain tests, which I directed him to make with different resin compounds against the Grape Phylloxera in the Sonoma Valley during September and October of the past year. The results have been fully as satisfactory as we anticipated, and the economy of the process is very striking, labor being practically the only expense.

Miss Mary E. Murtfeldt reports upon the insects of the season in eastern Missouri, and also gives the results of experiments which she has made with certain insecticides submitted to her from this office for trial. She also presents descriptions of four Microlepidoptera, which are new in the rôle of feeders upon Apple.

Prof. Herbert Osborn reports upon the insects injurious to forage-crops, meadows, and pastures in his State. His report last year was mainly taken up with the consideration of the Leaf-Hoppers, to which he gives some further consideration this year, adding some notes on locusts and crickets. He presents also a series of miscellaneous observations.

Mr. F. M. Webster devotes his report mainly to the Hessian Fly, discussing the number and development of broods, the effect of the larvæ upon plants, the effect of the weather on the development of the fall brood, and preventive measures. He also gives some notes upon three of the species of Plant-lice, found commonly upon wheat.

In presenting this bulletin for publication, I desire to thank these agents for the care with which they have followed out instructions and for the intelligent manner in which they have conducted these investigations.

C. V. R.

REPORT ON NEBRASKA INSECTS.

By LAWRENCE BRUNER.

LETTER OF SUBMITTAL.

LINCOLN, NEBR., *October 16, 1890.*

SIR: Herewith is submitted a report of my work in Nebraska for the year as special field agent of the Division of Entomology of the United States Department of Agriculture.

In addition to my observations on the general insect depredations within the State, I have incidentally given some time to the study of such insects as were taken upon the sugar and other beets during the summer.

This special study was undertaken at the suggestion of our experiment station director, who was quite anxious that "beet insects" should be made the subject of a special bulletin to be issued from the station some time during the coming winter. I accordingly include herewith a brief summary of the results of this special study.

Yours truly,

LAWRENCE BRUNER,
Field Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

The past summer has not been particularly noted as one in which insect depredators were especially abundant or destructive to the various crops that are raised in the State. In fact, taking the State as a whole, the injuries from this source have been rather less than is usually the case. No one species, so far as I have been informed, has been a pest during the year. The Corn Root-worm (*Diabrotica longicornis*), while it has spread some since my last report, was much less abundant than last year. Cut-worms did not appear in early summer so universally over the State, nor did they do anything near the damage they did the year past. No Army-worm depredations have been reported at the station, nor have any come to my own observation; while the Corn Ear-worm (*Heliothis armigera*) has been less destructive in most portions of the region along the Missouri River.

If any one insect has been on the increase and has caused more injury than usual, it was the almost universal Codling Moth (at least universal wherever apples are grown or eaten). But if this insect has become apparently more widespread within this region than it was

formerly, it is quite consoling to know that the warfare against it has also become more general. Almost every fruit-grower has at last come to the forced conclusion that warfare against this insect, at least, has become an absolute necessity, and has accordingly instituted a rigorous fight against it. The arsenious spray is the almost universal remedy resorted to with our fruit-growers here in Nebraska, as it is in other localities. Either London purple or Paris green are the poisons used, and where applied properly always result favorably to the orchardist.

THE GREEN-STRIPED MAPLE WORM.

The Green-striped Maple-worm (*Anisota rubicunda*) appeared quite numerous again in the towns and cities of Nebraska, and has done much injury to the Soft Maples (*Acer saccharinum*) growing along their streets. Here in Lincoln, the first or spring brood of larvæ was sufficiently numerous to defoliate many of the largest trees before they had become fully matured, and in that manner proved to be quite effectual towards self-extermination. Many of the larvæ actually starved to death; while others were so weakened from starvation that they either died in the chrysalis state, or else were so exhausted when they emerged as moths that there was but little egg-laying for a second brood. Some of the neighboring cities and towns were less fortunate, and had a much more plentiful fall brood of the larvæ, and hence will be well supplied with the insect next spring unless something unforeseen prevents it.

Considerable has been done in the way of remedies by the citizens of Lincoln against the second brood. Many of the moths were gathered and destroyed before they had time to deposit their eggs and later on in the season spraying the trees with London purple and Paris green was resorted to with good results.

While a moderately dry summer usually has the tendency to increase the number of most of our injurious insects, several such years immediately following one another have the opposite effect. So it has been with the summer which has just closed. The drought was so very marked that even the more hardy insect life was sensibly affected by its severity. Such species as had been favored by the scarcity of their more frail parasites during several years of moderate drought, this year were themselves, to a certain degree, sensibly affected by its continuance and severity.

LOCUSTS OR GRASSHOPPERS.

Locusts or grasshoppers of several species were quite numerous in certain localities, especially in cities away from the destructive influence of fowls and such other predaceous animals as are always at hand in the country ready to "gobble up" various insects. These locusts did some damage, of course, but not nearly so much as was done by them

last year. Whether this decrease in their numbers has been due to parasites or to disease, I can not say.

One noticeable fact in connection with the subject of insect depredations, in this particular region at least, is the growing interest which the general public is taking, and the tendency on the part of the people to help themselves against this host of insect enemies which is assailing them on all sides. Whether this interest is traceable to any particular source, or whether necessity is the awakening factor, I can not say. I trust, though, that my work in this direction has not been entirely in vain.

BEET INSECTS.

Ever since the Sugar Beet industry was first agitated here in the West, and now especially since the project has assumed such a practical form, it has become of general interest. For several years now the cultivation of the sugar beet has been a theme for much speculation, and to some extent also of experimentation. Now that a large factory has been built at Grand Island in this State, the sugar beet is to be one of our regular crops year after year. It will no longer be a plant that is grown out of mere curiosity or simply for experimentation.

It has been ascertained in connection with the culture of the sugar beet that certain insects show a tendency to attack and injure it. In this respect the beet is not any different from other cultivated plants; or, for that matter, wild or native ones also. In fact, it is too evident that certain ones of these insect enemies seem to prefer this "new" crop to any of these which have been cultivated in the same region for a considerable time.

It was therefore thought here at the experiment station, early last summer, that it might be well, as far as practicable in connection with other lines of work, to give some attention to these insect enemies of the sugar beet. Accordingly the following "press bulletin" was sent out over the State:

SUGGESTIONS IN REGARD TO THE SUGAR-BEET CULTURE.

Reports from the sub-stations established in the spring by the State Experiment Station for the purpose of determining the effect of the varying conditions of the soil and climate on the growth of and the production of sugar in the Sugar beet are in the main good.

In many places, especially in the extreme western part of the State, beets have suffered from hot weather and a lack of rain; as a rule, though, they seem to withstand these unfavorable conditions as well as corn and better than small grain.

From some points reports tell us that insect enemies have begun their ravages. * * *

As there are several kinds of insects that attack the beet, and as they have already been reported as having begun operations, it seems the proper time to begin to learn something of their appearance, habits, and the best means of meeting their advances. To this end the beets should be watched very carefully, from day to day and at different times of the day, and even in the evening, for any insect, bug, or worm that seems to have an interest in them; search the leaves, pull up the beets and search the

roots and the top layer of the soil, and when any marauder is found send it to the experiment station for study and identification.

Directions for sending such specimens I copy from Bulletin XIV on "Insects Injurious to Young Trees on Tree Claims," just issued:

"Whenever possible, insects should be packed alive in some tight tin box—the tighter the better, as air-holes are not needed—along with a supply of their appropriate food sufficient to last them on the journey; otherwise they generally die on the road and shrivel up.

"Send as full an account as possible of their habits; what part of the plant they infest, time of day when they are most active, amount of damage done, etc.

"Packages should be marked with the name of the sender and should be addressed to the entomologist of the Agricultural Experiment Station, Lincoln, Nebr."

It will aid very materially in forming conclusions if all people who have planted seed this season will send from time to time reports of the conditions of their beets to the experiment station.

Address:

H. H. NICHOLSON,
Agricultural Experiment Station, Lincoln, Nebr.

The very dry summer may have had considerable to do towards influencing much of the insect injury to the beets grown within the region designated, and some species of insects may have worked upon this plant that ordinarily would not have done so. In many localities various insects were observed to congregate among the leaf stems just above the ground that could not have been there for mischief, since they were such forms as do not feed upon growing plants. Especially was this true in portions of the State where the drought was severest and where other refugees from the burning sun and parched soil were scarce or entirely wanting. In many of these localities a great variety of insect life was always sure to be found hidden away during the day-time in such places. Not only beetles but also representatives of such other orders as the Hymenoptera, Hemiptera, Neuroptera, Orthoptera, Diptera, and Lepidoptera were quite common in such localities. Even many water-inhabiting forms frequently occurred in company with the others.

Of course all of these insects that were found on or about the roots of the beets were sent in to the station both by the field agents and by the various correspondents, who took an interest in the investigations under way. To separate most of these "refugees" from such other forms as might possibly be there for mischief was, of course, quite easily done at the station by those who were accustomed to the habits of most of the insects under consideration. A few of them were, however, more difficult to single out, and required special study to decide positively, which in nearly every case was accomplished.

In the study of this subject it was quickly demonstrated that almost all of the insect enemies of the sugar beet, as well as of the common garden and other varieties, were either weed feeders or else were such as are very general feeders. It was also ascertained that nearly if not quite all of the insects of whatsoever description that attack other

Chenopodiaceous plants, as the various species of "tumble weeds," the "pig-weed," *Atriplices*, etc., the purslane and other juicy weeds, as also many of those that attack the various Cruciferae and Solanaceae, will also feed upon the beet. Not a single species of insect has thus far been reported by any of the agents of the station, or by correspondents, that is exclusively a beet feeder. Every one of them has been ascertained to attack some one or more of the other plants that are also common to the region. Only a very few species have appeared in numbers sufficiently great to be what could be termed "destructive" to the beet within the region covered by these studies or investigations; and these few are of such a nature that they can be readily combated.

In their modes of attack upon the beet these various insects, so far as they have been studied, are either leaf-feeders or root-borers, *i. e.*, they either attack the foliage which they devour or from which they suck the juices by inserting their beaks, or they bore into or gnaw the roots. Later on in our investigations we may find that there are others that will attack the seeds and seed stems. In either of the former cases the result is an injury to the beet, whether it is being cultivated for the table, for feeding to stock, or for the manufacture of sugar. Should future study reveal others that attack the seed of the beet these latter would of course be of direct injury to the seed industry since much seed will necessarily have to be raised to provide for the large crops that are required each year for sugar.

Having now become fully convinced that the cultivation of the Sugar Beet is not without its drawbacks here in the West, and that there are insects which we must contend against and overcome in raising this crop, as well as in the raising of corn, wheat, and potatoes, we see the necessity of beginning our fight at once if we would prevent much future loss. By prompt action in the beginning, when the enemies are few in numbers and less generally distributed, we will have a much easier time of it; besides, our losses from this cause will be infinitely smaller than if we neglect them and permit them to go on increasing and spreading unmolestedly.

The following list embraces all such species of insects as were either found to injure the beet here in Nebraska or else have been recorded by others as attacking this plant within the region referred to:

LIST OF BEET INSECTS.

Species that attack the Leaves.

LEPIDOPTERA.

1. *Spilosoma virginica*, Fab.—The larva of this very common insect, is one of the first noticed to injure the beet. It also infests a large number of other plants.
2. *Spilosoma isabella*, Abb.—The larva, like that of the preceding, attacks the beet and many of our common weeds.
3. *Mamestra picta*, Harr.—Larva occasionally attacks the leaves of beet and other garden plants.

4. *Euryperon rantalis*, Guen.—The larva of this small Pyralid moth is one of our most destructive beet insects. It is the one usually known as the Garden Web-worm; and also attacks a number of other plants among which are the "Pig-weed," the tumble weed, purslane, etc.
5. *Manestra trifolii*, Rott.—Larva quite common on beets; and sometimes doing considerable injury by gnawing away the leaves and the entire tops of small plants. Also a purslane insect.
6. *Plusia brassicæ*, Riley.—The larva occasionally attacks the beet, but more commonly the turnip, cabbage, and other Cruciferæ.
7. *Deilephila lineata*, Fab.—Larva found feeding on beet leaves in Lincoln, Nebr., by Mr. H. Marsland. A very common purslane insect.
8. *Copidryus glomeri*, G. and R.—Taken several times on the leaves of beets which it had eaten more or less. An abundant purslane moth.
9. *Agrotis*, spp.—Several species of these "cut-worms" are occasionally quite destructive to the beet while it is still small. They work more or less all summer, but are most destructive early in the year. They cut off the plant just at or a little below the surface of the ground. Some of them also work upon the leaves above the ground.
10. *Leucania unipuncta*, Haw.—The Army Worm, when it is abundant, does considerable damage to beets and other garden plants by eating their foliage.
11. *Botis pecticata*, Grt.—The larva of this moth is said to be quite destructive to a number of plants here in the West. "In 1873 we found the larvæ feeding upon Helianthus, Ambrosia, potatoes, and beets, skeletonizing and ruining the plants for miles along the Neosho Valley and throughout Kansas," writes Professor Riley in the U. S. Agricultural Report for 1883.

ORTHOPTERA.

12. *Melanoplus femur-rubrum*, DeG.—Occasionally injuring the leaves of beets and other vegetables.
13. *M. atlantis*, Riley.—When common, a general feeder, at least upon the products of the garden and farm—beets of course included.
14. *M. spretus*, Thos.—Attacks the beet during times of invasions. Sometimes entirely eating away the leaves and portions of root that protrude from the ground.
15. *M. differentialis*, Thos.—When plentiful it occasionally does some injury to the foliage of the beet and other garden plants.
16. *M. bivittatus*, Say.—Where beets are planted on low ground or are growing close to some rank vegetation, it attacks their tops, but never does much damage.
17. *Dissosteira carolina*, Lin.—Found feeding upon the tops of sugar beets during the month of July, at McCook, Nebr.
18. *Trimerotropis latifasciata*, Scudd.—Taken in company with the preceding, also feeding on sugar beets.
19. *Spharagemon æquale*, Scudd.—Several specimens were received during the summer from McCook and Ravenna, Nebr., with the accompanying statement to the effect that they fed on the sugar beet.
20. *Pezotettix olivaceus*, Scudd.—I have seen this hopper in beet fields several times under such circumstances as led me to think it feeds upon that plant. It is also quite partial to Helianthus and Chenopodium.

COLEOPTERA.

21. *Diabrotica 12-punctata*, Oliv.—Quite common on the leaves of beets, which it injures by gnawing holes in them.
22. *Disomyela triangularis*, Say.—The beetle feeds upon the leaves of beets and other Chenopodiaceous plants. Sometimes quite common here in the West.

23. *D. cervicalis*, Lec.—Has similar habits to the preceding, but is less abundant.
24. *D. xanthomelana*, Dalm.—Common on beets and other Chenopodiaceous plants, the leaves of which it riddles with holes.
25. *D. crenicollis*, Say.—One of the 5-lined flea-beetles that occur here in moderate numbers; is also occasionally taken on beet leaves at Lincoln, Nebr.
26. *Systema frontalis*, Fab.—Found feeding upon beet leaves on the College farm, Lincoln, Nebr.; also on the leaves of *Hibiscus militaris* at West Point, Nebr.
27. *S. teniata*, var. *blanda*, Melsh.—A very numerous species in all parts of the State from which beet-feeding insects have been received. It literally riddles the leaves of beets with pit-like holes, in some instances entirely destroying the leaves of quite large plants. I have also taken it upon white clover, purslane, and amaranthus. This is liable to be one of our most destructive beet insects here in the West, especially in Nebraska.
28. *Psylliodes convexior*, Lec.—Another of the flea-beetles that is very abundant on the leaves of beets in some portions of Nebraska, and which works in a somewhat similar manner to the preceding.
29. *Chaetocnema denticulata*, Illig.—I found still another of our small flea-beetles at work on the beets growing on the State farm here at Lincoln, although in much fewer numbers than either of the two species preceding.
30. *Epitrix cucumeris*, Harr.—This small flea-beetle was found to be quite abundant at Ashland, Nebr., where it was taken by Mr. T. A. Williams, upon the potato, *Solanum nigrum*, and the beet, the leaves of all of which were more or less closely riddled with holes.
31. *Epicauta pennsylvanica*, DeG.—This black blister-beetle injures the leaves of quite a number of plants, prominent among which are the potato, "pigweed," and beet. It has been received at the station from central and western Nebraska as one of the most destructive insects attacking the plant.
32. *Epicauta cinerea*, Forst.—Another of these blister-beetles was found here at Lincoln by Mr. Herbert Marsland, who said it almost ruined a small bed of beets growing in his garden. I have also collected the same species from one of the wild beans and several other native plants.
33. *Epicauta maculata*, Say.—This insect has been received from Medicine Lodge, Kans., and from Grant and Neligh, Nebr., where it was found to injure the sugar beets by feeding on the leaves. It is a very common insect here in the West upon quite a number of the Chenopodiaceous plants, and especially upon the various species belonging to the genera *Chenopodium* and *Atriplex*.
34. *Epicauta vittata*, Fab.—This striped blister-beetle is also a beet insect; and has been received from Ogalalla, this State, where it was reported as doing much damage to sugar beets. It also is quite a general feeder. Among its food plants are to be mentioned the Solanaceæ, some of the Leguminosæ, and I have found it to be quite destructive to several of the Sagittariæ.
35. *Epicauta cinerea*, var. *marginata*.—This large black blister beetle also frequently gathers upon vegetables of different kinds in the semi-arid regions east of the Rocky Mountains, but chiefly upon beans. I have taken it on beets once or twice here in Nebraska.
36. *Cantharis nuttalli*, Say.—During the late summer and early fall of 1888 this insect was very destructive to garden plants, beets included, in the Black Hills of South Dakota. It also abounds in the western and northwestern parts of Nebraska.
37. *Colaspis brunnea*, Fab.—This small leaf beetle, which appears to be quite a general feeder, has been taken on several different occasions upon the beet both by myself and different ones of the field agents, and also by some of the correspondents.
38. *Epicarum imbricatus*, Say.—The Imbricated Snout-beetle has been known to attack the beet among the many other plants upon which it feeds. It is a general feeder.

39. *Centrinus penicillus*, Hbst.—Another of the Snout-beetles that attack the beets here in the West is the one known to the entomologist by the above name. It gnaws small holes in the leaf-stem, and when numerous does considerable harm to the plants attacked. Whether or not the insect breeds here I was unable to ascertain.
40. *C. persiculus*, Hbst.—Still a third species of weevil was found upon the beets growing on the State farm. It is a much commoner insect than *penicillus*, and works in a similar manner upon the leaf-stem.
41. *Apion*, sp.—This little Apion was taken on the leaves of beets here at Lincoln on two separate occasions.
42. *Doryphora 10-lineata*, Say.—The Colorado Potato-beetle was brought into my office at different times during the summer by those who reported its having been captured on the leaves of beet which it was “certainly eating.”

HETEROPTERA.

43. *Blissus leucopterus*, Say.—The Chinch Bug has quite frequently been taken by me upon beet tops in company with several others of the plant bugs. Whether or not it was there only temporarily, I can not say; but suppose it was, since all of our leading economic entomologists assert that its food-plants are limited to the grasses.
44. *Piesma cinerea*, Say.—A very common bug on the beet and various others of the Chenopodiaceous plants. Sometimes doing much damage to the leaves of the former.
45. *Nysius angustatus*, Uhl.—Another bug that often gathers upon the beet and other garden plants is what is called the False Chinch-bug. When numerous it often does considerable harm to the plants which it attacks. It is also one of the weed insects that enjoys a wide range.
46. *Geocoris bullatus*, Say.—The Large-headed False Chinch-bug, or Purslane Bug, is also much addicted to infesting the beet here in Nebraska. In fact it has been received from all over the State as one of the commonest of insects infesting the beet. It is also a great weed bug.
47. *Trapezonotus nebulosus*, Fall.—This bug also frequents the beet and several other Chenopodiaceous plants. It is especially partial to the Pigweed (*Chenopodium album*) here in Nebraska.
48. *Emblethis arenarius*, Linn.—Taken several times on the beet in company with the preceding. This insect also is a frequenter of localities where *Chenopodium album* is growing. The species also occurs about the roots of “Stink Grass” (*Eragrostis major*).
49. *Lygus pratensis*, Linn.—Probably one of the most general feeders among the true bugs, and sometimes a very destructive enemy of the beet. It occurs throughout the entire North American continent in the temperate regions.
50. *Euthoea galeator*, Fab.—This bug has also been taken several times on the beet in the vicinity of Lincoln, Nebr. I have collected it also from the wild cucumber (*Echinocystis lobata*).

HOMOPTERA.

51. *Agallia siccifolia*.—This little leaf-hopper, which seems to be especially partial to the different species of *Amarantus* and *Chenopodium* and allied weeds, is also equally fond of the beet, at least such would appear to be the fact, judging from the large numbers of the insect that are invariably to be found upon this plant all through the summer. It occurs in all stages.
52. *Immature forms only*.—Found in moderate numbers on the sugar beet at Grant, Nebr., a rather large leaf-hopper, which also occurs upon the *Amarantus* and *Chenopodium*.

53. *Allygus* sp.—This prettily marked leaf-hopper is very partial to *Chenopodium album*, on the under side of the leaves of which it breeds throughout the summer. This insect also attacks other species of the same genus, those of the genera *Amarantus* and *Montilia*, etc. Besides these it is very frequently found on the beet. Characteristic marks of its presence are the rather large purplish spots that are seen upon the leaves of plants that have been punctured by its beak.
54. *Erythroncra* sp.—Another small, slender, green leaf-hopper that is occasionally met with upon the beet.
55. *Athyas* (? sp.).—Still another of these leaf-hoppers that is found upon the beet.
56. *Liburnia intertexta*.—There is still a sixth of these leaf-hoppers that has been taken on the beet here in Nebraska; and which presumably also does some injury to that plant by sucking its juices.
57. *Aphis atriplicis*, Linn.—Mr. T. A. Williams tells me that he has taken this plant-louse on the beet at Ashland, this State, where it was quite common during the year.
58. *Aphis cucumeris*, Forbes.—This past summer Mr. Williams also took what he determined to be the *Aphis cucumeris*, Forbes, breeding quite abundantly upon some beets that grew right by the side of some cucumber vines that had been infested by the same insect.
59. *Siphonophora pisi*, Kalt.—The same gentleman tells me that he has also taken the common garden aphid here at Lincoln, on the beet. He found it in the pupa and winged stages.

Species that attack the Root.

COLEOPTERA.

60. *Ligyris gibbosus*, De G.—This beetle has been quite destructive to the sugar beet over limited areas towards the western part of the State during the present season. It attacks the root, into which the mature insect gnaws great holes, sometimes entirely imbedding itself. It worked most on old ground and where irrigation was resorted to. It worked on the roots from the surface to a considerable depth but most at about 3 or 4 inches below the surface. In some instances it reached a depth of fully 7 inches below the surface.
61. *Laenosterna fusca*, Fröh.—Not unfrequently the common white grub attacks the roots of the beet, and does injury to the plant in that way. There are very likely several kinds of the "grub" that are concerned in these attacks, since almost every locality has its particular species of "June bug" that predominates in numbers.
62. *Wire Worms*.—Several of the larvæ of "snapping beetles," or click beetles, are also to be charged with injuring the roots of beets in some localities.
63. *Unknown larva*.—On two different occasions during the past summer I found beets that had been attacked by some unknown larva just below the surface of the ground, and from which the depredator had already escaped. The work resembled that of an insect that works in the roots of different "tumble weeds" and causes them to break off. The larvæ are rather short, thick, whitish grubs with brownish heads, about one-fourth of an inch in length, slightly largest in the middle; possibly the larva of some snout beetle.

UNCERTAIN.

64. *Silpha opaca*, Linn.—This insect has been taken several times by me in beet fields, and in gardens where beets were growing. In Europe the insect is said to be quite injurious to the beet crop, by attacking and devouring the leaves. Whether or not it has the same habit in this country I can not say.

In addition to the above list of insects that are known to actually attack one or the other varieties of beet there are several others that

have been taken so frequently upon that plant, and under such peculiar circumstances, that they, too, may prove to be its enemies. Among these latter I would mention several of the Eleodes, one Collops, and several Diptera.

REMEDIES THAT CAN BE USED AGAINST BEET INSECTS.

It will be quickly seen by any one who has taken the pains to go over the foregoing list, that in nearly every case, at least so far as mentioned here, the insect enemies of the beet are identical with those that work upon our common garden weeds, or else they are such as are very general feeders. It will also be observed that most of them are leaf-feeders; *i. e.*, they nearly all attack that portion of the plant above ground. These being the facts in the case, the remedies that at once suggest themselves are simple. A spray of some kind scattered over the plants will be effectual as well as economical. The beet tops are seldom utilized for food, either for man or beast. Hence for protection against insects with gnawing mouth parts that attack them an arsenical spray can be used, whilst for such as receive their nourishment by means of a sucking mouth the kerosene emulsion will answer the purpose. This latter remedy will also be effective against No. 27, as has been demonstrated by actual experiment by at least one of our correspondents, who writes that "The kerosene emulsion which you directed me to try on my beets against the flea-beetles was a perfect success."

A direct as well as useful remedy is the careful destruction of all such weeds as furnish food for the same insects that attack the beet. Clean culture in this case becomes doubly necessary. First, to prevent the appropriation by the weeds of nourishment that should be taken by the beets, and secondly, to give less room for the propagation of injurious insects.

REPORT ON VARIOUS METHODS FOR DESTROYING SCALE INSECTS.

By D. W. COQUILLETT, *Special Agent.*

LETTER OF SUBMITTAL.

LOS ANGELES, CAL., October 8, 1890.

SIR: I herewith submit my annual report for the season of 1890. The Australian lady-bird (*Pedalia cardinalis* Mulsant) recently introduced by this Division, successfully survived the winter unprotected out of doors, and as early as the month of March I was able to distribute several colonies to those requesting them. Lest this species, after exterminating the Fluted or Cottony-cushion Scale (*Icerya purchasi* Maskell) should become extinct on this coast, our State Board of Horticulture, at the suggestion of its president, Hon. Ellwood Cooper, has erected two propagating houses over two large orange trees belonging to Col. J. R. Dobbins, in the San Gabriel Valley; in these houses the Vedalias are to be propagated and distributed to those requiring them. At the present writing it is no easy matter to find a single living *Icerya* anywhere in this part of the State, although in the early part of the season they appeared in limited numbers in a great many places; later in the season the Vedalias also appeared in considerable numbers, and by sending colonies of these to the different localities where the *Iceryas* had appeared, the latter were effectually held in check.

The Red Scale (*Aspidiotus aurantii* Maskell), so destructive to Citrus trees in certain localities, is rapidly reduced in numbers through the agency of the treatment with hydrocyanic acid gas, described in my previous reports. This treatment is now being largely used for the above mentioned purpose, and is giving far better results than have ever been obtained by the use of any kind of a spray; numerous instances have occurred where, upon large Citrus trees treated with this gas, neither myself nor other parties were able to find a single living Red Scale, either upon the bark, leaves, or fruit—a result which so far as I am aware has *never* been obtained by the use of any kind of a spray. The cost of treating trees with the gas is scarcely greater than that of using a spray, while the method has been so greatly simplified that trees can now be treated with the gas very nearly as rapidly as they can be sprayed. I have not as yet learned that any person, or even a single domestic animal, has ever been accidentally injured either by the gas itself or by the materials used in producing it. All of the objections which at first were urged against the use of this gas—the danger of being poisoned by it or by the chemicals used, the great expense attached to its use, and the impracticability of operating the tents—have finally been overcome, and the treatment is now in successful operation.

In my last report I gave an account of the spraying of a number of orange trees at Orange according to instructions. These trees were not again sprayed until the lapse of a little over one year. At this latter date the trees were again badly infested

with the Red Scale (*Aspidiotus aurantii* Maskell), although these were not so numerous as they were at the time that I had them sprayed a little over one year previously. The oranges when gathered in the following spring were quite free from the scales, none of them having been rejected by the purchaser on account of being too badly infested with these pests. Those who depend upon spraying for ridding their trees of these scales usually spray their trees twice a year, in March or April, and again in August or September, although some growers perform these operations only in the autumn, the second spraying being given to the trees about two months after the first.

During the past season I have received numerous favors from you, especially in the matter of identifying insects, for all of which please accept thanks.

Respectfully yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
United States Entomologist.

THE GAS TREATMENT FOR THE RED SCALE.

The process of treating trees with hydrocyanic acid gas for the destruction of scale insects (Family Coccidæ) is now being extensively used in southern California, not only in the orange groves, but also in the nursery where the imported trees are subjected to this treatment for the purpose of ridding them of insect pests. In Orange County alone fully 20,000 orange and lemon trees have been subjected to this treatment the present year in order to free them from the red scale (*Aonidia aurantii* Maskell).

Since the year 1887 various accounts of this process have been published in some of the Annual Reports and Periodical Bulletins of this Department.*

But as these are somewhat scattered, and include an account of the various improvements that have been made from time to time, I have thought it desirable to give in this place a brief account of this process as at present used in actual field work, including in the account such improvements as have been made since writing up my last report upon this subject. Briefly speaking, this process consists in covering the infested tree with an air-tight tent and afterward charging the tent with hydrocyanic acid gas. The material commonly used in the construction of the tent is what is known as blue or brown drilling. A few persons have used common ducking in place of the drilling, but this is much inferior to the latter; in the ducking the threads of which it is composed extend only lengthwise and crosswise, whereas in the drilling they also extend diagonally—this belonging to the class of goods to which our merchants apply the term "twilled"—and for this reason the drilling is both stronger and closer in texture than the ducking.

* See Annual Report United States Department of Agriculture for the year 1887, pp. 123-142; and 1888, pp. 123-126. Also INSECT LIFE, vol. 1, pp. 41, 42 and 286; and vol. II, p. 202-207.

After the tent is sewed up it is given a coat of black paint, as it has been ascertained that tents treated in this manner last longer than those which have been simply oiled with linseed oil. Some persons mix a small quantity of soap suds with the paint in order to render the latter more pliable when dry, and therefore less liable to crack. Instead of thus painting the tent some persons simply give it a coating made of an inferior grade of glue called "size," first dissolving this in water and then covering the tent with it, using a whitewash brush for this purpose. Sometimes a small quantity of whiting or chalk (carbonate of lime, CaCO_3), is added to this sizing with or without the addition of lamp-black. A few make use of the mucilaginous juice of the common Cactus (*Opuntia engelmanni* Salm.) for this purpose; to obtain this the Cactus leaves or stems are cut or broken up into pieces, thrown into a barrel and covered with water, after which they are allowed to soak for three or four days; the liquid portion is then drawn off and is ready for use without further preparation. Tents which I saw that had been prepared with this substance were to all appearances as air-tight and pliable as when prepared in any other manner.

A tent 26 feet tall by 60 feet in circumference—a size large enough to cover the largest orange tree now growing in this State—if made out of drilling, and either painted or sized, as described above, will cost completed about \$60. Where the trees to be treated are not more than 12 feet tall the tent can be placed over them by means of poles in the hands of three persons; to accomplish this, three iron rings are sewed to the tent at equal distances around and 6 or 7 feet from the bottom of the tent; immediately under each of these rings an iron hook is attached to the lower edge of the tent. When the latter is to be placed over a tree each of the hooks is fastened into the corresponding ring above it; one end of a pole is then inserted into each of these rings and the tent raised up and placed on the tree. The hooks are then released from the rings and the lower edge of the tent allowed to drop upon the ground.

Instead of allowing the tent to rest directly on the tree some growers use an umbrella-like arrangement, the handle of which is in two pieces, which are fastened together with clamps provided with pins; this allows the handle to be lengthened or shortened according to the height of the tree. This apparatus is put up over the tree and the tent allowed to rest upon it. By the use of this simple device the danger of breaking off the small twigs on the upper part of the tree by the weight of the tent is avoided. Mr. Leslie, of Orange, used four tents and tent-rests of this kind, and he informs me that with the aid of two men he fumigated 120 trees in one night. To remove the tent from one tree, place it over another, and charge the generator required only one minute and a half. In the place of poles some persons attach a circle of gas pipe to the lower edge of the tent; then two men, each taking hold of opposite sides of this circle, throw the tent over the tree. Dr. J. H. Dunn, of Pomona, informs me that four men, using six tents like the

above, fumigated 240 orange trees in one night, and that the average for each night was over 200 trees, the latter being 8 feet or less in height.

Trees over 12 feet tall will require a derrick of some kind for the purpose of putting on the tent and removing it again. For this purpose a stout mast is erected in the center of a strong framework mounted upon the running gears of a common farm wagon, the height of the mast depending upon the height of the trees to be operated upon. This mast is braced in four directions, and to the upper end of it is firmly attached a cross-piece, extending transversely to the length of the wagon, and long enough to reach from one row of trees to another. To each end of this cross-piece are attached small pulleys, through which pass ropes which are attached to the tents; by pulling down on these ropes the tents are drawn up to the cross piece after which the wagon is drawn ahead until the tents are directly over two of the trees to be treated; the ropes are then let out and the tents lowered down over the trees. The ropes are usually attached to the lower edge of the tents as well as to their apices, and when the tent is to be taken off of the tree the ropes attached to the bottom of it are first pulled downward, thus drawing the lower part of the tent up to the cross-piece first, and in a measure turning the tent inside out. But for this device it would be necessary to have the cross-piece at least twice the height of the trees to be operated upon. This apparatus is drawn between two rows of trees and the trees on each side of it treated with the gas. It is customary for the men themselves to draw the fumigator from tree to tree, thus doing away with the use of horses for this purpose. Stout planks are frequently used for the wheels of the fumigator to run upon. A fumigator of this kind, without the accompanying wagons and tents, can be built for about \$15, it being the cheapest and simplest apparatus ever used for this purpose. It has not as yet been patented, and is more largely used at the present time than any other kind, operating the tents successfully even upon the largest orange trees. The first fumigator of this kind was built by Mr. O. H. Leefeld, a prominent orange-grower of Orange, and a man who has had considerable experience as a machinist.

Within the past few weeks a new kind of a fumigator has been brought out by Mr. W. H. Souther, of Covina, Los Angeles County, Cal. This, like the preceding one, is mounted upon a common farm wagon, and operates two tents, one on either side of it. At each end of this fumigator are four upright posts attached at their lower ends to the framework, which is mounted on the wagon; the outermost posts are shorter than the inner ones, and to the upper end of each is attached a long spar by a hinged joint, which allows the spar to be moved back and forth transversely to the length of the wagon. The two spars on one side of the fumigator are connected with each other near their upper ends by means of a wooden cross-piece, and are drawn back and forth

by means of ropes passing through pulleys. The tents are operated by means of ropes, which pass through pulleys attached to the spars and cross-pieces described above, there being five ropes attached to each tent; one of these is attached to the apex of the tent, and passes through a pulley fastened to the middle of the above-mentioned cross-piece; two other ropes are attached to opposite sides of the tent, about midway between its apex and base, and pass through pulleys fastened to each of the spars near their upper ends; the other two ropes are attached to opposite sides of the lower edge of the tent and pass through pulleys fastened to each of the spars a few feet higher up than those above described. To the bottom of the tent is attached a wooden circle in several pieces, and the two ropes attached to the bottom of the tent are fastened to this circle; these ropes are not exactly on opposite sides of the tent, the space between them equaling about one-third of the entire circumference of the lower edge of the tent.

In taking the tent off of a tree the two ropes attached to the tent midway between its base and apex are first drawn downward until their points of attachment are slightly above the top of the tree, after which the two ropes attached to the lower edge of the tent are drawn downward until their points of attachment are drawn up against the spars at the places where the pulleys through which these ropes pass are fastened; the lower edge of the tent at this stage will be perpendicular to the surface of the ground, and these ropes are further pulled upon until the spars on this side of the wagon are perpendicular to the wagon, thus bringing the weight of the tent upon the middle of the wagon; the spars are prevented from going over backward any farther by the presence of the inner upright posts referred to at the beginning of this description. When both of the tents have thus been drawn upon the wagon the latter is moved forward until the tents are brought opposite the next two trees. Before the tents are again let down over the trees the fumigator is first braced up by means of four long braces attached to each of the four corner posts at a distance of about 8 feet from the ground; these are attached in such a manner that they may be swung out at right angles to the fumigator, or, when not in use, may be swung around and loaded upon the wagon without first detaching them. After these four braces are in position the ropes attached to one of the tents are let out and the tent allowed to fall down over the tree, a guide-rope being attached to its lower edge to aid in guiding it in its downward descent over the tree.

Mr. Souther, the inventor of this fumigator, informs me that a fumigator of this kind, without the wagon and tents, could be built for about \$60. He also informs me that a patent has been granted to him upon this fumigator.

Besides the above fumigators I may also mention one which has been used in a few instances with very good results. It is an extremely simple affair, consisting of an upright post the lower end of which is

attached to a framework on a wagon or sled, while to its upper end is attached a long stick of timber, the latter being attached near its middle to the top of the post, like the sweep of an old-fashioned well. The tent is then attached to one end of the sweep, and by pulling downward on the opposite end the tent is raised up, and may then be swung around and let down over a tree.

After the tent is placed over the tree the next step is to charge it with the gas. The materials used for the production of the gas consist of commercial sulphuric acid (K_2SO_4), fused potassium cyanide (KCN), and water, the proportions being 1 fluid ounce of the acid, 1 ounce by weight of the dry cyanide, and 2 fluid ounces of water. The generator is placed under the tent at the base of the tree; it consists of a common open earthenware vessel. The water is first placed in the generator, then the acid, and last the cyanide, after which the operator withdraws to the outside of the tent and the bottom of the latter is fastened down by having a few shovelfuls of earth thrown upon it. The tent is allowed to remain over the tree for a period of from 15 to 30 minutes, according to the size of the tree.

It was found by experimenting that the trees were less liable to be injured by the gas when treated at night than they were when operated upon in day time, and at the same time the gas is just as fatal to the scale insects when applied at night as it would be if applied in the day time; and indeed it appears to be even more fatal when applied at night. This is accounted for by reason of the fact that in the day time the light and heat decompose the gas into other gases which, while being more hurtful to the trees, are not so fatal to insects. At night the trees are also more or less in a state of rest, and therefore are not so liable to be injured by the gas as they would be in the day time, when they are actively engaged in absorbing nourishment and replacing wasted tissue with new materials.

Of the different materials used in generating the gas, the most important is the potassium cyanide; of this there are three grades: The mining cyanide, commercial cyanide, and the C. P. (chemically pure). Of these three brands, the mining cyanide is wholly unsuitable for the production of the gas, and the C. P. is too expensive; the commercial brand (fused) is the only one that is used for producing the gas, but even this varies greatly in strength, containing all the way from 33 to 58 per cent. of pure potassium cyanide. It is, therefore, of the utmost importance that the operator should know the exact percentage of pure potassium cyanide that his cyanide contains, and when large quantities of it are purchased at one time it would be advisable to obtain one or more analyses of it by a reliable analytical chemist; or if it is not possible to submit the cyanide to such person, an analysis of it could be made by almost any person accustomed to the use of chemicals or drugs.

The only substance required for this purpose is the crystals of nitrate

of silver (AgNO_3), which may be obtained at almost any well-stocked drug store. Dissolve the nitrate in cold water contained in a glass or earthen vessel, using one-fourth of an ounce (Troy) of the crystals to 1 pint of water; this dissolves in a few minutes, forming a whitish, semi-transparent solution. The cyanide, when dissolved in water, forms a transparent, nearly colorless solution; when a small quantity of the nitrate of silver solution is added to this it at first spreads out in a white cloud, like milk, but it soon breaks up into small, white, floccy pieces which gradually disappear upon being agitated, leaving the solution nearly as transparent as at first; when more of the nitrate of silver solution is added from time to time the above process is repeated, except toward the last, when the cyanide solution becomes somewhat milky, but it still remains semitransparent, permitting the operator to see quite clearly the bottom of the vessel containing the solution. As soon as a sufficient quantity of the nitrate of silver solution has been added to the cyanide solution the latter immediately becomes white and opaque, like milk, completely concealing from view the bottom of the vessel containing it. This completes the operation, and the quantity of nitrate of silver solution used will indicate the strength of the cyanide tested. When absolutely pure, $5\frac{3}{4}$ grains of the potassium cyanide dissolved in water will require 1 fluid ounce of the above nitrate of silver solution before the turbidity occurs, indicating that the cyanide is 100 per cent. strong; if only one-half of a fluid ounce of the nitrate of silver solution produces this turbidity, this indicates that the cyanide is only half strength, or 50 per cent. strong; if only one-fourth of a fluid ounce is required, then the cyanide is 25 per cent. strong; and so forth. The nitrate of silver solution should be added to the cyanide solution very slowly, the latter being agitated by gently shaking it each time that any of the nitrate solution is added. Wherever any of the nitrate of silver solution comes in contact with the skin or nails of the hand it produces a reddish or black stain which can easily be removed by washing the stained part in a solution of potassium cyanide and water; this will quickly remove the stain without causing any injury to the parts affected, except, of course, when the stains occur upon a sore or cut in the hand, in which case it would be very dangerous to apply the cyanide to these places.

It sometimes happens that the percentage of cyanogen (CN or Cy) is given, instead of the percentage of potassium cyanide (KCN or KCy); but in cases of this kind the percentage of cyanide can be readily ascertained by always bearing in mind that two-fifths of a given quantity of potassium cyanide is cyanogen. Thus if a certain brand of cyanide contains 24 per cent of cyanogen, this is equivalent to 60 per cent of pure potassium cyanide. Potassium cyanide when absolutely pure (equal to 100 per cent.) contains 40 per cent. of cyanogen; and, therefore, no grade of cyanide could contain a larger percentage of cyanogen than this.

The potassium cyanide used for producing the hydrocyanic acid gas is principally manufactured by two firms: Power & Weightman, of Philadelphia, Pa., and the Mallinkrodt Chemical Works, of St. Louis, Mo. That made by the first named firm is the most largely used; when purchased by the ton the price is 36 cents per pound for the grade containing about 57 per cent of pure potassium cyanide, packages and carriage extra. It is put up in tin cans holding 10 pounds each, and also in barrels holding about 400 pounds each. That in the cans is much to be preferred, since the quantity in each is so small that it will soon be used up after the can is opened; whereas, the barrel containing so large a quantity, the cyanide used toward the last will have lost much of its strength by contact with the air. It is customary to weigh out the cyanide in small paper parcels, and mark each parcel with the number of ounces of cyanide that it contains; then when the tree is to be fumigated it is an easy matter for the operator to select one of the parcels containing a sufficient quantity of the cyanide for the tree, thus saving the trouble of weighing out the cyanide as it is to be used for each tree. As the fumigating is done only at night the weighing of the cyanide is frequently done by the ladies of the house upon the day preceding its use.

The quantity of cyanide to be used on each tree will, of course, depend not only upon the size of the tree but also upon the strength of the cyanide used. The following table will aid in determining the proper quantity of each ingredient to be used on different sized citrus trees, the cyanide being about 58 per cent pure:

Height of tree.	Diameter of tree-top.	Water.	Sulphuric acid.	Potassium cyanide.
<i>Feet.</i>	<i>Feet.</i>	<i>Fluid ozs.</i>	<i>Fluid ozs.</i>	<i>Ounces.</i>
6	4	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
8	6	2	1	1
10	8	$4\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$
12	10	8	4	4
12	14	16	8	8
14	10	10	5	5
14	14	19	$9\frac{1}{2}$	$9\frac{1}{2}$
16	12	16	8	8
16	16	29	$14\frac{1}{2}$	$14\frac{1}{2}$
18	14	26	13	13
20	16	36	18	18
22	18	52	26	26
24	20	66	33	33

Not only is this gas fatal to the Red scale (*Aspidiotus aurantii* Maskell), but also to the San José scale (*Aspidiotus perniciosus* Comstock), and indeed to all of the armored scales. It is also fatal to the Brown scale (*Lecanium hesperidum* Linn.) and to the Black scale (*Lecanium oleæ* Bernard), but the eggs of this species are not affected by it. The common Red Spider (*Tetranychus telarius* Linn.) and the Woolly Aphis (*Schizoneura lanigera* Hausmann) are also not affected by the gas when used strong enough to destroy the Red scale, although I have known it to prove fatal to true spiders (species not determined). House-flies (*Musca domestica* Linn.), Lace-winged flies (*Chrysopa* sp.), and cer-

tain kinds of Ichneumon flies (*Ophion macrurum* Linn.) are also destroyed by the gas. On one occasion I obtained a cluster of eggs of a species of Psocus fly (*Cacilius aurantiacus* Hagen) that were deposited upon a leaf of a tree before the latter had been treated with the gas, and from these eggs afterwards issued a number of parasitic flies belonging to the family Proctotrupidae and to the genus *Alaptus*; but the species is as yet undescribed. Various kinds of Lady-birds, which are in the tree when the latter is treated with the gas, become stupefied and fall to the ground, but finally recover and are to all appearance none the worse for their temporary loss of consciousness. Birds, lizards, and even barn-yard fowls sometimes refuse to leave the large orange trees while the tent is being let down over them at night, and are therefore inclosed in the tent and subjected to the gas; the latter proves fatal to all of these. The small, pale yellow mites which are frequently found on orange trees, especially beneath the dead scales, are not affected by the gas; these have a general resemblance to the young of the Red scale, and several operators, finding these mites still alive after the tree had been subjected to the gas, came to the erroneous conclusion that the gas had not been effectual, thinking that these mites were the young of the Red scale.

From the above it will be seen that the gas treatment is not a sure specific for every kind of insect pest, but for destroying Red scales on citrus trees it is far superior to any other method at present known.

THE RESIN WASH FOR THE SAN JOSÉ SCALE.

During the past winter I carried on quite a series of experiments with various kinds of washes for the destruction of the San José scale (*Aspidiotus perniciosus* Comstock) on dormant deciduous trees, kindly placed at my disposal by Mr. C. H. Richardson, the inspector of fruit pests for the Pasadena district, Mr. Richardson also aiding me in making many of these experiments. Among all of the washes tried the following gave the best results:

Resin	pounds..	30
Caustic soda (70 per cent)	do.....	9
Fish oil	pints..	4½
Water, enough to make	gallons..	100

For making 100 gallons of the above wash a kettle holding 30 gallons will be required. Place all of the ingredients in the kettle and cover with water to a depth of 4 or 5 inches, boil briskly for about 2 hours, or until it will dilute evenly with water, like black coffee, which it closely resembles in color. When this stage is reached the kettle should be filled up with water, adding this very slowly at first; the contents of the kettle can then be emptied into a tank or other vessel, and a sufficient quantity of water added to make 100 gallons. Care should be taken not to chill the wash by adding large quantities of cold water at one time.

The making of this wash will be greatly accelerated if the resin and caustic soda are first pulverized before being placed in the kettle; if in large pieces, a considerable length of time will be required in which to dissolve them. If a sufficient quantity of water is not used at first the materials when dissolved will form a thick, pasty mass, which simply breaks open in places to allow the steam to escape, and pieces of the mixture will be thrown out of the boiler or against its sides or lid by the escaping steam. When this occurs, water should be added until the solution boils up in a foamy mass. Whenever there is a tendency to boil over a small quantity of cold water should be added, but not too much, or the making of the solution will be retarded; after a few trials the operator will learn how much water to add in order to prevent the solution from boiling over and yet keep it in a brisk state of ebullition. If it is not desired to add all of the water at the same time that the solution is made, then enough can be added to equal two-fifths of the quantity required; the balance of the water can then be added at any subsequent time without again heating the solution. Thus, if a sufficient quantity of the solution is boiled to make when diluted 100 gallons, this could first be diluted to make only 40 gallons, and the remaining 60 gallons of water added at any time as required. If it is desired to use it in a still more concentrated form than this, it need not be diluted at all after it has been boiled sufficiently, but in this case it will be necessary to heat it again before adding the water.

On the 11th of February, between the hours of 1:30 and 4:20 p. m. (sun shining, light breeze), I had 60 dormant deciduous fruit trees sprayed with the above solution. These consisted of peach, plum, apple, pear, and quince trees; none of them had started to leaf out except the quince, which had put forth a few leaves at the tips of some of its branches. Each of these trees was infested with the San José scale (*Aspidiotus perniciosus* Comstock) and several of them had been almost killed by the attacks of this pest. April 23 I made a careful examination of these trees and found only a very few living San José scales; all of the trees except those which were nearly dead when sprayed were now making a vigorous growth. May 12 I again examined these trees, and found living San José scales on only three of them, about half a dozen scales on each. I made another examination on the 11th day of June, and found a few San José scales on some of the pears on the above trees. All of the Black scales (*Lecanium oleae* Bernard) which I found on these trees were dead, and their eggs were dry. July 24 I again examined these trees and found three or four living San José scales on a few pears and apples on some of the trees, but the fruit was practically clean, whereas on adjoining trees which had not been sprayed nearly all of the pears were very badly infested with these scales. There was, however, a singular exception to this: A LeConte pear tree that stood in the midst of several Bartlett and Winter Nelis pear trees, which were very badly infested with the San José scale, was,

wholly free from this pest. Nor is this an isolated case, since I saw the same thing in another pear orchard located several miles from this one. Mr. Richardson informs me, however, that the fruit of this tree is almost worthless.

Wishing to test the effects of the above wash on growing trees, I sprayed a prune, peach, apricot, apple, and orange tree on the 12th day of May, between the hours of 10 and 11 a. m., sun shining, light breeze. I examined these on the 11th of June; on the prune all of the fruit had dropped off, and upon one-third of the leaves were dead brown spots, these spots not exceeding one-sixth of the entire surface of any of the leaves; on the peach all of the fruit was dead, but still clinging to the tree, and half the leaves had brown spots in them, these leaves being much more injured than were those on the prune tree; on the apricot the fruit was not injured in the least and three-fourths of the leaves were uninjured, but the remaining leaves had small brown spots in them, these spots not exceeding one-fifteenth of the surface on any of the leaves; on the apple all of the fruit had dropped off and half the leaves had large brown spots in them, these spots sometimes exceeding one-half of the entire surface of the leaf; on the orange nearly all of the fruit had dropped off (the young oranges being about half an inch in diameter), but the leaves were uninjured.

This indicates that of the different kinds of fruit thus experimented upon the apricot was the hardest and was the least affected by the wash; next to the apricot is the orange, then the prune, after this the peach, the apple having suffered most from the effect of the wash.

The orange tree experimented upon was infested with the Yellow scale (*Aspidiotus citrinus*), and also with the Black scale (*Lecanium oleae* Bernard), and all of these, as well as the eggs of the Black scale, were destroyed by the wash.

According to the scale of prices furnished me by the Los Angeles Soap Company of this city, the material for making 100 gallons of the above wash, when purchased in large quantities, would amount to \$1.14, being but a trifle over 1 cent a gallon for the diluted wash.

The materials used in preparing the above wash are the same as those I used in spraying orange trees last season for the destruction of the Red scale (*Aspidiotus aurantii* Maskell), an account of which is given in my report to Professor Riley for last year, published in Bulletin No. 22 of the Division of Entomology (pp. 10-14); but the spray I then used was only three-fifths as strong as the one I used for the destruction of the San José scale as above described. On the 19th of December I tested the spray of the same strength that I had used for the Red scale on orange trees, but it did not prove fatal to all of the San José scales that it came in contact with.

The question as to the manner in which the above resin spray proves fatal to the scale insects—whether the caustic property imparted by the caustic soda is the destructive agent, or whether it is the suffocating

effect of the resin and fish oil saponified by the caustic soda that produces this result—is a very important one. Quite a number of our fruit growers were at first inclined to believe that it is the caustic property of the wash that destroys the scale insect, and they therefore increased the quantity of this particular ingredient, only to find that the wash so constituted is not apparently more fatal to the insects, while at the same time it is very liable to injure the fruit. My own studies and experiments lead me to believe that the above sprays kill for the most part by suffocation. In the course of experimenting I found that a wash composed of the following ingredients:

Caustic soda.....	pounds..	8
Resin.....	do....	33
Water enough to make	gallons..	100

did not prove fatal to as large a percentage of Red scale as did one consisting of:

Caustic soda.....	pounds..	6
Resin	do....	20
Fish oil.....	pints..	3
Water enough to make.....	gallons..	100

Now, if it is the caustic property of the wash that proves fatal to the scale insects, it is evident that the wash containing the largest amount of the caustic agent would prove fatal to the largest number of scale insects, but the reverse of this was really the case; the wash containing the smallest amount of the caustic agent, the caustic property of which was still further lessened by the addition of the oil, proved fatal to the largest number of the insects. On the other hand, the addition of the oil, while reducing the caustic property of the wash, would increase its varnishing qualities, since it is a fact well-known to painters that the addition of oil to a varnish improves its qualities. For these reasons it seems quite certain that it is the suffocating properties of the wash and not its caustic nature that cause it to prove fatal to the scale insects which have been sprayed with it.

I have seen orange trees that had been sprayed with a wash so caustic that it killed fully nine-tenths of the leaves on the trees, burnt the bark brown, and caused nearly all the oranges to drop off, and yet quite a number of the Red scale insects located on the oranges still remaining on the tree were alive. This will show the utter uselessness of attempting to destroy the Red scale on citrus trees by the use of caustic washes.

THE LIME, SALT, AND SULPHUR WASH FOR THE SAN JOSÉ SCALE.

For destroying the San José scale (*Aspidiotus perniciosus* Comstock) on dormant deciduous fruit trees many growers in this State use a wash composed of the following ingredients in the proportions here given:

Sulphur	pounds..	33
Lime.....	do....	42
Salt.....	do....	25
Water enough to make.....	gallons..	100

All the sulphur and half of the lime are placed in a kettle and 33 gallons of water added, after which the contents of the kettle are boiled briskly for about 1 hour; the solution will then be of a very dark brown color and having a reddish tint. All of the salt is added to the remaining 21 pounds of lime and the latter slaked, after which this slaked lime and salt are added to the above described sulphur and lime solution and the whole then diluted with a sufficient quantity of water to make 100 gallons; this is then strained, after which it is ready to be sprayed upon the trees.

This does not form a perfectly liquid solution but contains a considerable quantity of undissolved sulphur and lime, which soon settles to the bottom unless the solution is stirred almost constantly while being sprayed on the trees. It is therefore somewhat of the nature of a thin whitewash, and the trees sprayed with it have the appearance of having been whitewashed. On the 26th of November, at 12:45 p. m., sun shining, light breeze, I sprayed a pear tree with a wash made according to the above directions, the tree being very thickly infested with the San José scale. January 15 I found 14 living San José scales on this tree, and on the 23d of April I found several more; on the 11th of June I found on this tree a Black scale (*Lecanium oleæ* Bernard) containing healthy eggs.

I also tested this wash in the following proportions:

Sulphur.....	pounds..	50
Lime	do.....	63
Salt	do.....	37
Water enough to make.....	gallons..	100

This was applied to a pear tree at 1 p. m., November 26, sun shining, light breeze. On January 15 I found 6 living San José scales on this tree, and on the 23d I found several more.

At the time of making these tests there were several green leaves on each of these trees, but all of these were killed by the washes. The trees otherwise were not apparently injured, and in the following spring started into a vigorous growth which was continued throughout the summer. These trees were not over 10 feet tall, and were very thoroughly sprayed, so it seems quite certain that every scale insect located upon them must have been covered with the wash.

The philosophy of this wash is not at present clearly understood. It seems very probable however that the product of the lime and sulphur (bisulphide of lime, CaS_2) furnishes the insecticidal property, and the presence of the salt and slaked lime simply imparts permanency to the wash. I made quite a series of experiments with the above-named ingredients, with a view of ascertaining which of the ingredients were really insecticides, but these experiments have thus far resulted negatively. The following is a brief account of these experiments:

SALT.—Experiment 229: Table salt, 19 pounds; water, 100 gallons. I simply dissolved the salt in cold water and then sprayed the solution

on a pear tree at 12:30 p. m., November 26, sun shining, light breeze. This did not kill all of the green leaves that were upon the tree. January 15 I found a great many living San José scales on this tree.

Experiment 228: Salt, 38 pounds; water, 100 gallons. Dissolved the salt in water as before and sprayed on a pear tree at noon, November 26, sun shining, light breeze. This killed all of the green leaves that were upon the tree. January 15, I found many living San José scales on this tree.

Experiment 237: Salt, 60 pounds; water, 100 gallons. Dissolved the salt as before and sprayed on a pear tree at 10 a. m., January 20, sun shining, light breeze. April 23, I found a great many living San José scales on this tree.

SALT AND LIME.—Experiment 238: Salt, 25 pounds; slaked lime, $8\frac{1}{2}$ pounds; water, 100 gallons. The salt and lime were added to the cold water, stirred occasionally, and strained through a piece of Swiss muslin and then sprayed upon a pear tree at 10:30 a. m., January 30, sun shining, light breeze. April 23 I found a great many living San José scales on this tree.

SALT AND SULPHUR.—Experiment 232: Salt, 25 pounds; sulphur, 75 pounds; water, enough to make 100 gallons. The sulphur was boiled for an hour in 75 gallons of water, after which the salt was added, and the solution diluted with a sufficient quantity of cold water to make 100 gallons. After standing for a few minutes the greater portion of the sulphur settled to the bottom, making it necessary to stir the solution almost constantly while applying it to the tree. Sprayed on a pear tree at 2:45 p. m., November 26, sun shining, light breeze; this killed all of the green leaves on the tree. January 15 I found a great many living San José scales on this tree.

SULPHUR.—Experiment 233: Sulphur, 100 pounds; water, enough to make 100 gallons. Placed the sulphur in the water and boiled for 1 hour, then when cold, sprayed the solution on a pear tree at 3 p. m. November 26, sun shining, light breeze. This did not injure any of the green leaves that were on the tree. January 15 I found a great many living San José scales on this tree, a smaller proportion being killed than in either of the preceding experiments.

LIME.—Experiment 239: Slaked lime, 10 pounds; water, enough to make 100 gallons. The lime was placed in the water, stirred occasionally and in two hours the solution was strained through a piece of thin Swiss muslin and sprayed upon a pear tree at 10:45 a. m. January 20, sun shining, light breeze. April 23, I found a great many living San José scales on this tree.

LIME AND SULPHUR.—Experiment 240: Quicklime (CaO), 100 pounds; sulphur, $33\frac{1}{3}$ pounds; water, enough to make 100 gallons. Placed the lime and sulphur in a copper vessel, added 30 gallons of water, and boiled for two hours, then filtered. The solution was of a deep orange-red color. After standing for a few minutes needle-like crystals

somewhat resembling the down on the seeds of thistles separated out. These were composed of bisulphide of lime (CaS_2) and being freely soluble in water, were dissolved when the balance of the water was added. In this action all of the sulphur had been incorporated with the lime, since the residue when dried would not ignite. Added a sufficient quantity of water to the above solution and sprayed an apple tree with it at 10:30 a. m. March 18, sun shining, light breeze.

About 14 hours after making the above experiment it began to rain very gently and this was continued for 24 hours. April 23, I found a great many living San José scales on this tree. At the time of making the above test I also sprayed some of the solution on a branch of a peach tree in full blossom, but this did not appear to produce any injurious effect upon the blossom, since at the time of my visit on the 23d of April this branch bore as many peaches as did any of those I had not sprayed. It seems almost certain that the rain, coming on so soon after the wash was applied, rendered neutral the effect of the above solution on the scale insects sprayed with it. I have seen orange trees that had been sprayed with the resin wash on a certain day and a rain occurred during the night following the application; but the wash did not prove fatal to nearly as large a percentage of the red scales as would have been the case had no rain occurred.

On the same day that the above test was made (March 18), I also tried the above mentioned lime and sulphur solution at half strength, but it did not produce any apparent effect upon the San José scales infesting the tree sprayed with it. It was now too late in the season to make additional tests of this solution, but I hope to be able to follow up this subject during the coming winter.

From the above experiments it would appear that neither lime, salt, nor sulphur when used separately are effectual in destroying the San José scale; and the same is true in regard to any two of them when used in combination, except, perhaps, the lime and sulphur, which have not as yet been sufficiently tested. It is very probable, however, that these two ingredients give to the wash its insecticidal property, while the addition of the slaked lime and salt simply impart stability to the wash, rendering it less liable to be washed off the trees by the winter rains. Should this surmise prove correct, then the directions given at the head of this article for preparing this wash should be changed, an equal number of pounds of lime being required with the 33 pounds of sulphur, instead of only 21 pounds of lime, as at present used.

I experienced considerable difficulty in preparing and applying this wash, owing to the fact that some of the materials used are not soluble in water, necessitating an almost constant stirring of the solution while it is being sprayed upon the trees. On this account it is quite impossible to spray it uniformly upon all of the trees, and this difficulty has also been experienced by each of our fruit-growers who have used it and with whom I have conversed upon the subject, or who have written

to me in regard to it. Some of the trees sprayed by this solution would be very much whitened, as if whitewashed, whereas other trees sprayed from the same tank as these would be scarcely discolored by the wash. It is, of course, the slaked lime added to the solution that causes it to give the trees the appearance of having been whitewashed, since neither the salt nor the sulphur discolor the tree to any appreciable extent, and the same is true of the bisulphite of lime, which is produced by boiling the quicklime and sulphur together.

The cost of 100 gallons of this wash according to prices furnished me by Howell & Craig, wholesale grocers, of this city, for the sulphur and salt, and by the Southern California Lumber Company, also of this city, for the lime, is as follows, the materials being purchased in large quantities:

Sulphur, 33 pounds, at $2\frac{1}{2}$ cents per pound.....	\$0.70
Lime, 42 pounds, at $\frac{7}{8}$ of a cent per pound	.33
Salt, 25 pounds, at $\frac{9}{10}$ of a cent per pound	.11
Total	\$1.14

The salt quoted above is a poor grade, such as is used for salting hides, and the price quoted is by the ton; the sulphur is in sacks, and the lime in barrels containing about 220 pounds each.

Of the two washes above described—the resin, caustic soda, and fish oil, and the lime, salt, and sulphur washes—the one containing resin is greatly to be preferred. Not only is this wash easier to prepare than the other, but it is also much easier to apply it to the trees, since it is perfectly soluble in water and therefore does not require to be stirred while being sprayed upon the trees. For this reason more uniform results will be obtained by its use than would be obtained by using the sulphur wash. Moreover, the resin wash, by being properly diluted, can also be used in the summer season, and thus only one wash need be used at any time of the year. In my own experiments better results were obtained by the use of the resin wash than were produced by the sulphur wash. The price per gallon of each of these washes is about the same. The sulphur wash should never be used on trees in leaf nor on those just starting to leaf out, and this is also true of the resin wash when made according to the formula given in the preceding article.

MISCELLANEOUS EXPERIMENTS.

CORROSIVE SUBLIMATE (also known as mercuric chloride, HgCl_2).—Some time ago one of the Horticultural Commissioners of San Bernardino County remarked to me that he had used a simple solution of corrosive sublimate for the purpose of destroying various kinds of scale insects on nursery trees, and had obtained very good results by the use of the same; and it was also reported in some of the San Diego papers that a gentleman living in that county had obtained better results by the use of a solution of the above kind than he had by using any other kind of insecticide for the destruction of the black scale.

Thinking the subject worthy of investigation, I made a few experiments with this substance, but the results were far from being satisfactory. I dissolved the sublimate in cold water by frequent stirring; this required about 15 minutes, and the solution was of a dark bluish-gray color. Following is a brief account of these experiments:

(224) Corrosive sublimate, $2\frac{1}{4}$ ounces; water 100 gallons. Sprayed on an orange tree infested with the red scale at 3 p. m., October 10, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(223) Corrosive sublimate, $4\frac{1}{2}$ ounces; water, 100 gallons. Sprayed on an orange tree at 2:30 p. m., October 10, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(236) Corrosive sublimate, $11\frac{1}{6}$ pounds; water, 100 gallons. Sprayed on a dormant pear tree infested with the San José scale at 10 a. m., December 31, sun shining, light breeze. February 3, found a great many living San José scales on this tree.

The price in this city of the corrosive sublimate in 10-pound lots is at the rate of \$1.40 per pound; at this rate the strongest solution I used (experiment 236) would cost about \$1.63 per 100 gallons. I did not test a stronger solution than this, since its cost alone would prevent its being extensively used.

GLUE.—For the purpose of testing this substance as an insecticide for the destruction of the red scale on citrus trees I made a few experiments with it, but with very unsatisfactory results. The grade I used is of a light brown color, not the white, nor yet the poorest grade, but such as is used by cabinet-makers. To dissolve the glue I simply boiled it in water, and it dissolved in about 10 minutes. Following is a brief account of these experiments:

(227) Glue, $4\frac{1}{2}$ pounds; water 100 gallons. Sprayed on an orange tree infested with the red scale at 4:30 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(226) Glue, 8.1 pounds; water 100 gallons. Sprayed on an orange tree at 4 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(225) Glue $12\frac{1}{4}$ pounds; water 100 gallons. Sprayed on an orange tree at 3:30 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

In this city (Los Angeles) the price of glue of the above grade in 10-pound lots is at the rate of 50 cents per pound; at this rate the strongest solution I used (experiment 225) will cost \$6.25 per 100 gallons. This, of course, is much too expensive for ordinary use as an insecticide, and for this reason I did not test a stronger solution.

ALOES.—Dr. M. F. Bishop, of Alameda, the owner of a large orchard of deciduous fruit trees in the vicinity of San José, in the northern part of the State, gave me a package of aloes, with the request to test it on the scale insects infesting citrus trees. Accordingly I made a few tests with it, simply dissolving the aloes in cold water, straining the solution through a piece of Swiss muslin, and then spraying it upon the tree. The aloes is not readily soluble in cold water, and 4 days were required for it to dissolve, being occasionally stirred during this time. The experiments are as follows:

(243) Aloes, 12½ pounds; water, 100 gallons. Sprayed on an orange tree infested with the yellow scale (*Aspidiotus citrinus*) at 10:30 a. m., March 22, sun shining, light breeze. April 23, leaves and fruit uninjured; found many living yellow scales on this tree.

(242) Aloes, 25 pounds; water, 100 gallons. Sprayed on an orange tree at 10 a. m., March 22, sun shining, light breeze. April 23, leaves and fruit uninjured; found several living yellow scales both on the leaves and fruit of this tree.

The price of the aloes in large quantities is at the rate of 16 cents per pound; at this rate the strongest solution I used (experiment 242) would cost \$4 per 100 gallons. At this strength (25 pounds of aloes to 100 gallons water) it proved fatal to a large percentage of the scale insects, and doubtless if it had been used one-half stronger it would have been entirely effectual; but the high price of a solution of the latter strength would prevent its being used on a large scale.

REPORT OF EXPERIMENTS WITH RESIN COMPOUNDS ON PHYLLONERA, AND GENERAL NOTES ON CALIFORNIA INSECTS.

By ALBERT KOEBELE.

LETTER OF SUBMITTAL.

ALAMEDA, CAL., October 20, 1890.

SIR: I herewith submit report upon experiments, chiefly with resin compounds, on *Phylloxera vastatrix*, and observations made during the year.

Very respectfully,

ALBERT KOEBELE,
Field Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

By your direction a series of experiments was carried on, chiefly with resin compounds, upon the *Phylloxera* in Sonoma Valley during September and the beginning of October.

In preparing the compounds the following were used: Bicarbonate of soda, sal soda, and Greenbank's caustic soda, 98 per cent. Three pounds are required of the former to dissolve 4 pounds of resin properly, or, in other words, to make a resin soap; 1 pound of the latter is sufficient to dissolve 10 pounds of resin or even 11, but I did not succeed in dissolving 12 pounds, as parts of the resin would always remain. In repeated and careful trials this could not be overcome.

The results showed somewhat in favor of the bicarbonate of soda as far as to destruction of the insects, but the price has to be considered. Next to this seems to be the emulsion prepared with caustic soda, but it is a difficult matter to decide which will work best without carrying on an extensive series of trials. It is safe to say, however, that the results will not vary greatly.

One pound of resin was used to each 10 pints of compound, and this again was diluted with water at a strength of 1 pound of resin in $2\frac{1}{2}$ gallons of water, up to 1 pound in $37\frac{1}{2}$ gallons of water—one part of compound in thirty parts of water. This compound will, as has been previously stated, do effective work on unprotected Aphids, *i. e.*, such as are not covered with cottony or mealy exudations, at one part in

fifteen parts of water, or 1 pound of resin in about 16 gallons of water. (The former mixtures were somewhat stronger; 1 pound of resin in 9 pints of liquid.) The action upon the Phylloxera is much more marked and with a mixture of one part of compound in thirty parts of water the insects, if immersed for a few seconds only and left exposed, will die, notwithstanding this solution will not adhere to parts of the roots, not having at this strength the required penetrating power which a sufficiently strong solution, say about 1 pound resin in 15 gallons of water, has, and more so than any other insecticide I know of. The experiments were made on 25-year-old Tokay vines (the only ones remaining that have withstood the ravages of the Phylloxera), in loamy soil, which was completely dry and hard at this time of the year, no moisture being noticeable until a depth of from 10 to 12 inches below the surface was reached.

In all cases the ground was removed to a depth of about 6 inches, forming a hole 4 feet in diameter. Ten gallons of the solution, it was observed, penetrated here to 12 inches in depth around the roots where the hole was deepest, or about 18 inches from original surface of ground, and most of the insects were destroyed to about 16 inches in depth, if the 10 gallons contained 4 pints of compound. In the later experiments these holes were made only about 2 feet in diameter, and nearly if not the same results were obtained with only half the amount or 5 gallons of the mixture. This is more practical, as the chief roots only are reached and the solution can be used so much stronger. The less solution required the better, providing it will do the work, for at 10 gallons to each plant this would mean 7,000 gallons or over per acre. If the solution is applied at another time of the year, say early spring, when rain is still expected, the results undoubtedly will be still more favorable. I have had excellent results with solutions prepared with caustic soda by using 4 pints of this to 16 pints of water only and applying 5 gallons of water soon after and 5 gallons the following day. This destroyed the Phylloxera to nearly the depth the fluid reached. Thus it will be seen if a small amount of the mixture, sufficiently strong, be applied in early spring the following rains will do the rest. As it was, with the dry soil, the 4 pints of compound in 10 gallons of diluent did better work than the same amount of compound in only 5 gallons, for the simple reason that it penetrated farther and thus reached more of the insects in sufficient strength to kill. It must also be remembered that a completely dry soil will take up a large amount of the liquid, whereas in a moist soil this is not the case.

The compounds were prepared as formerly, sal soda 3 pounds, resin 4 pounds, dissolved together with 1 quart of water, and water added slowly while boiling to make 40 pints. The caustic soda, which comes in 10-pound tin cans, is dissolved in 4 gallons of water, after which 4 gallons more should be added. This lye will dissolve 100 pounds of resin and make 125 gallons of compound, sufficient for 250 plants, and

costing at wholesale in San Francisco (T. W. Jackson & Co., No. 104 Market street) \$2.50. This is sufficiently strong, and to use more is unnecessary, as it was found that even 3 pints of the emulsion to the plant would do the work.

I will give here a receipt for preparing the cheapest compound. This is with common caustic soda, such as is sold at wholesale at about 5 cents per pound :

Caustic soda, 77 per cent.....	pounds..	5
Resin.....	do...	40
Water to make.....	gallons..	50

First the soda should be dissolved over fire with 4 gallons of water, then the resin added and dissolved properly, after which the required water can be given slowly while boiling to make the 50 gallons of compound. This will make 500 gallons of the diluent, sufficient for 100 plants, and costing about 84 cents.

While a much weaker solution would kill the *Phylloxera*, this is recommended, as it also destroys their eggs effectively. Below are given the results of some of the experiments to show the effects of various strengths. Most of these have been duplicated or tried upon several plants. A small mite (*Tyroglyphus* sp.), always very abundant among the *Phylloxera*, and, as a rule, feeding upon the sap of the roots, yet from numerous empty skins appearing to feed also upon the lice, was in no case injured by these resin washes.

COMPOUND NO. 1.—*Bicarbonate of soda, 3 pounds ; resin, 4 pounds, and water to make 40 pints, costing 15 cents.*

Compound, 1 gallon ; water, 6 gallons ; in holes 4 feet in diameter. Destroyed insects to about 12 inches in depth from original surface, as well as the eggs of the same, which became dark in color.

Compound, one-half gallon ; water, 4 gallons. Destroyed all insects where they were reached (occasionally a living one running about).

Compound, 1 part ; water, 10 parts ; about 10 gallons of the fluid used. This will destroy all lice and their eggs completely to 12 inches from original surface, but not deeper.

Compound, 1 part ; water, 12 parts ; $9\frac{3}{4}$ gallons used. Twenty-four hours after application some of the solution remained still on top, and on examining 6 days later it was found that it had penetrated the ground to 12 inches from original surface. Much of the solution had evaporated and left a brown scum (dry soap) on top. It will also destroy most, if not all, of the eggs.

Compound, 1 part ; water, 14 parts. Three and three-fourths gallons of the diluent in holes 2 feet in diameter killed the insects to 8 inches in depth, or 14 inches from original surface.

Compound, 1 part ; water, 16 parts ; $8\frac{1}{2}$ gallons diluent. Occasionally a living insect found and large numbers of mites on the nearly dead vines.

Compound, 1 part; water, 18 parts; $9\frac{1}{2}$ gallons diluent; examined 5 days after. Nearly all the insects dead to 14 inches in depth, but most of the eggs looked bright yellow and no doubt will hatch. Behind the thick bark near the top, where apparently the solution did not penetrate, a number of young lice were found alive.

Compound, 1 part; water, 20 parts; $10\frac{1}{2}$ gallons diluent; in holes 4 feet in diameter. An examination 5 days later showed the fluid had penetrated the ground on plants $15\frac{1}{2}$ or 20 inches from original surface. All the insects were destroyed 13 inches in depth and but very few living 3 inches deeper. This solution seems to work best of all this series, but it is doubtful if the eggs will be affected by it.

COMPOUND NO. 2.—*Caustic soda*, 98 per cent., 1 pound; *resin*, 10 pounds; *water to make* $12\frac{1}{2}$ gallons; *compound costing* 25 cents.

Compound, 4 pints; water, 4 pints; in hole 4 feet in diameter; 5 gallons of water added 1 hour later and the same quantity next day. Very few dead insects were found upon this plant, and none living. Not sufficient to show proper result.

Compound, 4 pints; water, 2 gallons; 5 gallons of water added 1 hour after and 5 gallons the following day. Examined plants 7 days later; result very satisfactory, hardly any living phylloxera as far as the fluid reached. After examination 5 gallons more water were added and again examined a week later, when no living insects could be found to a depth of 18 inches.

Compound, 4 pints; water, 10 gallons. Destroyed insects to about 8 inches in depth and but few below this.

Holes only 2 feet in diameter; 5 gallons of water in same first, and solution 1 hour later in the four succeeding experiments.

Compound, 4 pints; water, $4\frac{1}{2}$ gallons; examined 13 days later. Destroyed insects and eggs as well, which had become very dark. Occasionally a live specimen running about.

Compound, 3 pints; water, $4\frac{1}{2}$ gallons. Examined 13 days later and found all insects dead that had been reached.

Compound, $2\frac{1}{2}$ pints; water, $37\frac{1}{2}$ pints. Examined 13 days later. A piece of root about 10 inches deep one-half inch in diameter by 6 inches long and completely covered with phylloxera showed but one single living young, probably hatched from egg after application.

Compound, 2 pints; water, $4\frac{1}{2}$ gallons; also examined at the end of 13 days. All insects to 8 inches below ground or 14 inches below original surface were destroyed, as well as a large part of the eggs. Occasionally a living young was found wandering about.

Four other experiments were made with this compound, using 1, 2, 3, and 4 pints in 20 of the solution, the ground having 4 hours previously been saturated with 5 gallons of water in each case. Examined 12 days after; results were not good with 1 pint but were progressively better with the other three. Applied 4 gallons more water on plants where 3

and 4 pints had been used, and found 2 days later that this additional water still increased the effect.

In addition to this a number of plants were treated with this compound to note the results next spring. The holes were made 2 feet in diameter, and after the solution had disappeared the wet ground from the outside was placed around the plant and the hole closed again. The experiments were: Five pints of compound in 5 gallons of the solution, four plants; 4 pints of compound in 5 gallons of the solution, eight plants; 3 pints of compound in 5 gallons of the solution, ten plants; and 2 pints of compound in 5 gallons of the solution, ten plants.

COMPOUND NO. 3.—*Caustic soda, 98 per cent, 1 pound; resin, 8 pounds; and water to make 10 gallons of compound, costing 22 cents.*

Compound, 4 pints; water, $7\frac{1}{2}$ gallons. Examined 6 days later; result good.

Compound, 4 pints; water, 10 gallons. Examined 6 days later and found result favorable.

Compound, 3 pints; water, 75 pints. Found only part of insects destroyed 6 days later.

Compound, 3 pints; water, 90 pints. There were not enough insects upon this plant to deduce fair results, which would no doubt be very poor.

COMPOUND NO. 4.—*Sal soda, 3 pounds; resin, 4 pounds; and water to make 5 gallons of compound; costing 11 cents.*

Compound, 4 pints; water, $7\frac{1}{2}$ gallons. Examined 5 days later and found all insects killed except a few living on a plant under thick bark, where solution apparently did not penetrate.

Compound, 4 pints; water, 10 gallons. Examined 5 days later and found insects dead to 12 inches in depth from original surface, with only occasionally a live one walking about.

Compound, 3 pints; water, 75 pints. On examining, 5 days later, only the insects near surface were found dead.

Compound, 4 pints; water, 15 gallons. This destroyed only partly the lice near the top.

The following four experiments were made with this compound, the ground having been previously soaked with 4 gallons of water:

Compound, 3 pints; water, 21 pints. Examined 12 days later. Did not show good results, as part of the insects were found alive. Twice the amount of water with the same quantity of compound will do much better work.

Compound, 3 pints; water, 33 pints. Examined 12 days later and found results fairly good. Only a few living ones were running about.

Compound, 2 pints; water, 30 pints. On examination numerous live insects were found, but more than half were killed.

Compound, 2 pints; water 38 pints. Result about the same as in preceding experiment.

These four experiments were repeated and the water added (3 gallons) 2 hours after instead of before application of emulsion. The results in this case were much more satisfactory, destroying most of the eggs in the two first experiments and nearly all of the phylloxera in the two last to a depth of about 10 inches.

GENERAL NOTES.

It was probably owing to the unusually heavy rainfall during last winter that insects were comparatively scarce in the early part of the season. At least no complaint was noticed or heard during this time. While a large number would undoubtedly be destroyed by weeks of excessive rains and floods, yet there are such as are not or only slightly affected by this element. I may cite here, for instance, such species the eggs of which are found upon trees and shrubs during the winter months as well as the eggs of locusts usually deposited on dry hillsides. On a visit to Sonoma county during May, the larvæ of *Clisiocampa* were extremely abundant. Two species were found, namely, *C. constricta* and *C. thoracica*. The first species predominated in numbers, and while usually feeding upon deciduous oaks was also found upon Live Oak and *Quercus agrifolia* as well as various shrubs. In confinement these larvæ were furnished with food consisting of leaves of Plum and Cherry, but for three days they would not feed upon these and readily attacked the leaves of Live Oak which were given them, and upon these they were raised. *C. thoracica*, which is the species defoliating various fruit trees, was found chiefly upon willows, but also upon oaks, and here again usually upon White Oak, upon which its eggs were found in October. This species was bred upon leaves of Prune and Cherry.

At the end of May of the present year, I received from Mr. F. L. Washburn, entomologist of the experiment station at Corvallis, Oregon, a few *Clisiocampa* larvæ new to me. He said they were found feeding upon a species of *Crataegus* and were sent with leaves of apple, upon which I reared them. On my visit to Washington these larvæ were met with at Tacoma, on June 8, within webs upon Alder (*Alnus rubra*), and again at Easton, during July, upon Willow. Near Tacoma I also found what I took to be the larvæ of *C. thoracica* very abundant upon *Crataegus*, Alder, Hazel, and various other shrubs. Two of the larvæ were taken to Easton, and one pupated and to my surprise produced not the expected *C. thoracica*, but *C. erosa* Stretch.

About 10 miles along the railroad in southern Oregon, about the beginning of June, larvæ and webs of one of these moths were seen in large quantities on dry hillsides upon *Purshia tridentata* DC., *Ceanothus* sp., and also Wild Cherry. While crossing the Columbia River on steamer, June 8, at which time the water was very high, large numbers of these larvæ were observed floating upon the swift current and as

many as a dozen could be seen at one time, but of all the hundreds seen very few were dead. They were usually in a half-circle and completely dry above and were carried off to be distributed safely along the shores. In both cases I had no opportunity to obtain specimens for identification.

As to the parasites, so far two species of a small Chalcid were bred from 37 egg masses of *C. constricta* found within three hours while collecting Cynipid galls in Sonoma County during October. This species is preyed upon by Tachina flies, which are or have been, the present season, the chief agent in destroying them. From about two hundred grown larvæ collected but very few moths were obtained, the Tachina maggots issuing from the dying and spun-up larvæ in large numbers. No ground for their reception had been furnished in breeding cases and they pupated among the leaves and excrement. At least 80 per cent of these larvæ were parasitized and but one of the flies has issued up to date. I also obtained one large cocoon of an Ichneumonid from larvæ in confinement and others were still found in nature during September.

C. thoracica was also infested by Tachina larvæ, but only about 30 per cent. were destroyed by these maggots. Two species of the flies have come out so far. *C. californica* was noticed full of eggs of these flies and some had previously been bred. An Ichneumonid was obtained from young larvæ the present year. Professor Rivers, of Berkeley, informed me the end of April that he had previously observed one of these larvæ at Bay View upon Willow, and accordingly a trip was made to that locality and this species was found as well as its tents, not alone upon Willow, but also on the scrubby Live Oaks growing there, Hazel, Wild Currant, *Rhamnus californica*, Blackberry, and other plants, showing that this species is not confined to Live Oak alone.

No Tachina has yet been obtained from the species in Santa Cruz Mountains, nor have I observed any eggs, but larvæ of this species placed upon Cherry and Prune at Alameda were badly attacked. The same species of Ichneumonid bred from larvæ of *C. californica* has also been obtained from this. This species was observed upon Plum, Prune, Willow, *Ceanothus* and *Cercocarpus*.

Two species of Ichneumonids were bred from the new species of the north, one from larvæ found at Tacoma, and the second from those found at Easton.

I may mention one Noctuid larva as very destructive to buds, young fruit, and foliage of fruit trees, chiefly Apple, Pear, Plum, and Prune. This is *Taniocampa*, and I have full proof that the destruction of a large share of the buds and young fruit, so universally, yet incorrectly, attributed to birds on this coast, is due to this larvæ. In the very early spring, often in February, these moths make their appearance from hibernated chrysalids and copulate, and the female deposits her

eggs, from two to three hundred or more, in crevices of bark. I found them in large numbers together, thrust deep into a place where one of the branches had broken off. The young larvæ soon made their appearance and in want of leaves began to feed upon buds and blossoms, and later on, as I have repeatedly observed on apple trees, upon the young fruit also. Within about 24 days these larvæ become full grown and enter the ground for pupation to remain in this state for nearly 11 months. If only one or two early broods occur upon a single ordinary tree, they will, in some cases, destroy most if not all the fruit buds before any leaves appear. The light green, white, variegated, and striped larvæ at rest on the under side of leaves during the daytime are not, especially by an untrained eye, very readily discovered, and hence are overlooked and the more innocent bird is made responsible for the damage done.

During April, 1888, when I had a brood of these larvæ in confinement at Alameda, a common titmouse, *Lophophanes inornatus* Gamb., was noticed flying constantly to an old apple tree and carrying off dozens of these very larvæ to a hollow tree not far distant, within which it had a nest with six young. These birds are quite plentiful at this time of the year and are the only enemy of this larva as yet observed. None of the numerous larvæ collected the present year appear to be parasitized.

By jarring the trees in the early morning these larvæ, especially the larger, will fall to the ground, and can readily be collected and destroyed. If the tree be only slightly shaken, all the mature larvæ will drop.

Caloptenus devastator, so well remembered since its outbreak in 1885, has again been on the increase the present season and is quite abundant in Sonoma County as well as around Alameda, where *Camnula pellucida* was equally as numerous. Aside from complaints in Sonoma County others were heard of in Yolo County. I quote from the Woodland Democrat of September 11, 1890:

For the past few weeks our farmers have been watching their alfalfa crops very closely. The Army Worm and the Grasshopper are both here, although not in such quantities as in the early days. In some cases the crops in young vineyards have been entirely destroyed by them. C. Eakle lost all his grapes by the grasshoppers, and others have shared a like fate. In other cases the alfalfa crops have fared badly from the effects of the worm and the hopper. Mrs. P. Hannum had saved some alfalfa for seed, but the worm attacked it, and she was obliged to cut it for hay in order to save any of it. Mr. Hopkins, we understand, was caught in the same predicament, while the pastures of those who have lately irrigated and where the clover is just beginning to grow nice and green are full of the hoppers, and the worms have also attacked many others.

As yet no specimens from the above locality can be obtained, but it is more than likely that the injury was caused by several species and the Devastating Locust among them. One favorable season, however, should no parasites appear, would again show a marked increase in destructive numbers, and local outbreaks may be expected the coming summer.

ENTOMOLOGICAL NOTES FOR THE SEASON OF 1890.

By MARY E. MURTFELDT.

LETTER OF SUBMITTAL.

KIRKWOOD, ST. LOUIS COUNTY, MO.,

October 31, 1890.

SIR: Inclosed please find summary of my notes on injurious insects for the present year, as observed throughout the season in St. Louis County, and as compiled from correspondence with and occasional visits to other sections of the State. As in preceding years, many thanks are due you for various determinations and helpful suggestions.

Respectfully, yours,

MARY E. MURTFELDT.

Prof. C. V. RILEY,

U. S. Entomologist.

GENERAL OBSERVATIONS.

The season of 1890 throughout the Mississippi Valley has been in many respects unusual. The winter months were characterized by a temperature much above the normal, by occasional very heavy rains, and, after the middle of January, by a prevalence of clouds and excessive moisture. Many shrubs, for example Forsythia, Cydonia, and Lilac bloomed in the open air about the holidays, while the buds of all fruit trees were much swollen, and peaches and apricots opened their blossoms in sheltered situations in February. During early March the mercury for the first time in the year dropped to the neighborhood of zero, and on the last day of the month occurred a phenomenal fall of snow. April also was cold and damp, and similar weather prevailed until the middle of May, the soil, except where drainage was exceptionally good, being in poor condition for planting. With the first of June excessive heat set in, and for seven consecutive weeks the mercury was seldom below 90° F. at midday, and usually approached or exceeded 100°. This extreme heat was accompanied by an equally severe drought for the same length of time, scarcely mitigated by two or three very slight and very local showers.

That the effects of such a season should be plainly marked on insect life is not surprising. The following memoranda show considerable deviation from the records of preceding years.

Chinch Bugs were not reported as injurious in any part of the State, and scarcely a specimen could be found during midsummer and early autumn.

Canker Worms.—Very few, and found mostly in orchards or on trees standing somewhat above the general level. The male moths were flying every month during winter, and an occasional female was also seen in January and February. Probably the severe cold of March destroyed a large proportion of the very young larvæ, more perhaps by retarding the development of the apple leaves than by the direct effects of the cold.

Of the few worms that were found later in the season taking their noonday siesta on the trunks and larger branches of the trees, quite a number were seen which had evidently been attacked by some Carabid or other predaceous species, the skin having been punctured and the fluids oozing out with every motion. All injured worms perished, but what the assailant was I was not able to discover.

Cutworms (Agrotis and Hadenæ).—Vegetable gardens in the spring enjoyed an immunity from these pests that was most welcome to the gardener. This was probably due to the fact that some of the most destructive species hibernate in the larva state, and the degree of cold not being sufficient to reduce them to complete dormancy they perished of starvation and dampness or fell victims to the birds, which remained with us in greater numbers than is usually the case. My memoranda show that very few Noctuid moths of any kind were taken at light previous to the middle of August. To this scarcity of Noctuid pests there were, however, two notable exceptions—that of *Gortyna nitela* and *Heliothis armigera*, which have seldom committed so great injuries to certain crops as during the present year. About the middle of June many samples of young corn and potato stalks were sent me that were being bored by the first-named larva, and it was then reported from some localities—among others from Kidder, Missouri—as having destroyed fully one-half the crop of potatoes. Its injuries to young corn were also extensive, but I have no data for making an estimate. It was also found in considerable numbers, when very small, in small grain. In this it could scarcely reach maturity, and probably migrated to the stalks of such more succulent plants as were conveniently near. In the case of the attack on potatoes a treatment with Paris green and flour was recommended, on the probability that in passing from one stalk to another the worm would obtain a sufficient quantity of the poison to destroy it. Of the success of this experiment, if tried, I have not been informed. It did not occur in any noticeable numbers in the vicinity of Kirkwood.

Heliothis armigera was very destructive on both early and late corn,

especially on the latter. In the southern part of the State it injured the tomato crop to a considerable extent. Spraying with Paris green and with other arsenical compounds was tried with considerable success previous to the ripening of the fruit, but there is considerable danger in its use and it is best to thoroughly drench the plants that have been treated with clear water a day or two after the use of the insecticide. Experiment on a limited scale shows that it can be kept from corn by the same remedies, but how far this would be practicable in the field has not yet been demonstrated.

The Striped Flea-beetles (*Phyllotreta vittata* and *P. sinuata*) did not appear at all on early Crucifers, nor have they been observed in any considerable numbers in this vicinity at any time during the growing season. Whether this notable riddance was due to atmospheric conditions or to the scarcity of the fostering weeds, *Lepidium* and *Arabis*, I am not able to decide.

The Corn Flea-beetle (*Chaetocnema pulicaria*) was reported to me from various localities as unusually numerous and injurious. Mr. Falcon, of St. Clair County, feared that he should lose his first planting from its attacks, but from later accounts the plants recovered more rapidly than he had expected.

The Plum Curculio was much reduced in numbers during winter, and as there was in this section, and indeed throughout the State, an almost entire failure of stone fruit crops, with the exception of the sour cherries, which the insect rarely attacks, there was very little of the work of the latter observed. A small proportion of the few early peaches that set were punctured, but that the midsummer drought prevented the development of the larvæ was indicated by the fact that such late peaches as there were did not show a single one of the food punctures which commonly so disfigure them. On one tree which the previous year had suffered so much in this way that the fruit was absolutely worthless, was a single peach that reached perfection without one stroke from the beak of a curculio; and similar observations were made on other trees on which a very little fruit ripened. Nor was I able to find *Conotrachelus* breeding in apples, although during June and July I examined nearly six hundred specimens of fruit, a few of which showed punctures that might have been made for food. Should other conditions be favorable, I think, so far as this insect is concerned, we may predict for 1891 fine crops of stone fruits.

Plant lice, always quite abundant in the spring, amounted this year almost to a scourge. Trees, shrubs, and herbs alike suffered, and for many plants there was no after-recovery. The species causing the most appreciable loss was probably the Grain Aphis (*Siphonophora avenæ*). It occurred throughout the State on all small grain, even on rye, causing, undoubtedly, some shrinkage of that crop as well as of wheat, but its most disastrous attacks were on oats. About the middle of May farmers began to be alarmed for the safety of this crop, and subsequent

developments proved their fears to be well grounded. Letters of inquiry and packages of specimens came to me from all directions, and during a trip about the first of June, to Butler County, on the southern boundary of the State, I was able to observe for myself the dwarfed and sickly appearance of small grain everywhere along the railroad, attributable in all cases to the attacks of this insect. Shortly afterward the outfields in St. Louis County and in many other localities were plowed up and replanted to corn, which, owing to the drought and to its own insect enemies, was, in its turn, a poor crop. The unusual prevalence and unparalleled multiplication of *Aphidide* was undoubtedly due to the scarcity of their natural enemies, both parasitic and predaceous. It was not until the middle of June that the larvæ of *Syrphidae*, *Coccinellidae*, and *Chrysopa* became numerous, and, reinforced by parasites of the genera *Aphidius* and *Trioxys*, finally brought relief from the pests; too late, however, to prevent irreparable injury to many herbaceous crops, young fruit trees, and various sorts of shrubbery.

A somewhat remarkable development of the season was the appearance in unusual numbers of many insects not often accounted noxious, and the reappearance of some species not observed in this locality for many years.

Among the former may be mentioned the great abundance and variety of "stinging" larvæ, principally *Limacodes*. For the first time in my experience the beautiful larvæ of *Parasa chloris* were so abundant on some young apricot trees in the orchard of one of our neighbors as to do great damage to the foliage. When full grown, three-fourths or more of an inch in length, thick, oblong, sub-cylindrical, gaily striped longitudinally in carmine red, purple, and bright yellow, the stinging spines concealed in the two rows of deflected bright yellow plumes that adorn the back, gliding with slow, graceful motion over the leaves, they were almost too ornamental to doom to destruction. As they were very voracious, however, the latter was a necessity of the case. Those that were preserved were fed to maturity on the leaves of Chickasaw plum, to which they were transferred without difficulty.

Euclea querceti H. S., of the same form and size as *P. chloris*, but much less brilliantly colored, being of a dull, mottled green, with two or four dark purple-red spots on each side of the dorsum, and having the plumose spines pale green, appeared on Plum, Cherry, and Apple in the orchard, as well as on Sycamore, Post Oak, and Wild Cherry in the forest. It was not, however, in any destructive numbers on any fruit tree.

So far as coloration is concerned this larva varies greatly. The crimson sub-dorsal spots, usually quite large when there are but two, are in some examples smaller and less conspicuous and are followed posteriorly by a second pair. The longitudinal ridges on which these are situated, and from which also proceed the larger urticating spines, vary in hue from pale pea green to yellow and bright orange. A second

variety was so distinct as to be described, previous to breeding, as another species. This is entirely of a pearly, translucent white color, with fine, wavy, purple lines, one on each side of medio-dorsal space and two others lower down on each side inclosing the second row of spines, which, like the general surface, are translucent white. There is a large purple spot a little back of the middle on each side of the dorsum. I have found this variety only on pear, and it is rather rare. The cocoon is spun among the leaves and does not differ in color, form, or texture from those of other *Limacodes*. The moth bred from this pale larva does not differ from those of typical *quereeti*, being of a rich fustic brown, with bright green and velvety black ornamentation. In the size of the green and black spots and in general intensity of color a series of moths of this species also exhibit considerable variation.

The almost equally beautiful and even more strikingly marked Saddle-back Caterpillar (*Empretia stimulca*) occurred in very unusual numbers on Plum, Pear, Chestnut, Maple, and Wisteria vine, doing considerable damage—especially during the semi-gregarious period, which continues to the third molt—to the foliage of the fruit trees attacked.

Phobetrion pithecium and *Limacodes scapha* were other species of this group observed.

Lagoa crispata was quite numerous on White Oak and Chestnut, and colonies of *Saturnia io* appeared on Corn and Sassafras and defoliated several rose bushes in our garden before we discovered the authors of the mischief. Altogether there was quite an array of "urticators," and gloves were very necessary to preserve the hands of the collector in taking them and also in caring for them in the rearing cage. They seem to dispense stinging points all over the foliage over which they crawl and all about the cage in which they are confined. I have often had my hands smart for hours after changing the leaves and cleaning the cage in which these larvæ had been reared, long after they were inclosed in their cocoons.

There was throughout this and contiguous States a notable outbreak of *Datana* both *D. angusii* and *D. ministra*, but especially the former. This species appeared on the Walnut in June, and the second brood again in August, and from the excessive and repeated defoliations it is probable that many fine trees have been destroyed.

During a journey taken about the 1st of September, numbers of trees were noticed bearing what would have been a heavy crop of nuts, but absolutely leafless, while the trunks were almost covered with larval exuvæ. The nuts were, of course, small and imperfect, the shrunken husks clinging to the seed. Several collections of the walnut-feeding larvæ were sent me, but not having a supply of walnut leaves convenient, I was not able to rear any of them, as they refused to accept as a substitute the leaves of hickory or of *Rhus glabra* or *copalina*, although some years ago I bred them from the latter.

During September the black-necked larvæ of what I suppose will

prove to be *D. ministra*, Drury, appeared on post oaks in Kirkwood and vicinity, defoliating portions of the trees infested. From their gregarious habit and their susceptibility to poison they were easily routed. Even a stream of water turned upon them from the spraying pump would dislodge and bring them to the ground, where they were easily killed.

Orgyia leucostigma, a species formerly abundant in this locality, but which I had not observed for ten or twelve years, was found on Sycamore (*Platanus*), on which, strange to say, it would not feed after the second molt, and consequently all caterpillars left on the tree perished before attaining half their growth. The question suggested by this observation was how the young larvæ came to be upon this tree which so evidently did not suit them for food. I could not find either cocoon or egg mass of the mother insect, nor were any of the larvæ discovered in the adjacent orchard.

Ichthyura inclusa, another species not observed here for many years, appeared on willows in great numbers in September, but coming so late in the season the defoliations did no serious damage.

In concluding these notes I wish to mention an insect that will probably prove most efficient in ridding the country of the pest of the Web Worm (*Hyphantria cunea*). This is the larva of a small and inconspicuous Carabid of the genus *Plochionus*, bearing the appropriate specific name *timidus*. I had observed during the month of June that the greater number of the webs of the caterpillar were unusually small and incomplete and seemed to have been deserted much sooner than usual.

Before I had time to investigate the matter, I received from Mr. J. C. Duffey, horticulturist at the Shaw Botanical Garden, a colony of the worms, interspersed among which were numerous small active Carabid larvæ, which Mr. Duffey informed me were preying upon the former. The collection was placed in a cage and arranged for convenient observation, and I very shortly had ocular demonstration of the correctness of Mr. Duffey's assertion. Many interesting observations were made upon these small but ferocious larvæ before they changed to pupæ, and the appearance of the perfect insect was awaited with much interest. The first beetle developed about the middle of July and proved to be the species named.

Comparatively few webs of the second brood of *Hyphantria* were seen in and around Kirkwood in August, and extensive examination revealed the fact that fully three-fourths of these also contained larvæ of *Plochionus*, which were busily engaged in reducing the numbers of the rightful inhabitants. Nor is the beetle confined in its diet to the web worm. I found the larvæ repeatedly during the present autumn in the masses of leaves webbed together by the somewhat gregarious larvæ of a Tortrix (*Cacaccia ferridana*) and between the two leaves webbed by various Tineids, especially *Cryptolechia nubeculosa* and *C. schlegellerella*. (I doubt not I may have occasion to deprecate its work in the future

in these groups.) That this *Plochionus* had not appeared this season much to the east of St. Louis was evinced by the much webbed and defoliated orchard and forest trees noticed in Illinois and Indiana in August and September.

As Mr. Duffey proposes soon to publish a history of the insect, with detailed descriptions of its various stages, I defer offering my own notes upon its habits and forms until after the appearance of his paper.

A FEW MORE INJURIOUS MICROS ON APPLE.

A very considerable number of Microlepidoptera, including *Pyratidæ*, *Phyeitidæ*, *Tortricidæ*, and *Tineidæ*, have already been characterized and catalogued among the more or less injurious insects of the orchard and garden; but the observations of almost every year add to this list, and I propose here to briefly describe a few which have not as yet been placed on the roll, but which in this locality are annually so numerous as to commit appreciable injury.

PENTHINA CHIONOSEMA, Zell.—The larvæ of this beautiful species were, last year, uncommonly abundant during the month of May on the leaves of apple, particularly in young orchards. They fold the leaves at the midrib, or sometimes one edge over to the midrib, fastening the edges all around firmly and feeding upon the inclosed upper surface.

Larva.—The larva is not especially characteristic, being of a pale opaque green color, without maculation, except the rather inconspicuous glassy piliferous plates. Head pale yellow, tinged with green, legs similarly colored; length from 16 to 17^{mm}; diameter, 3^{mm}. Form subcylindrical, tapering but slightly either way from middle.

When full grown it incloses itself under a rolled edge of the leaf, lining and strengthening the tube thus formed with a white silken web. The moth appears early in June, and I have no record of a later brood, although there may be one.

The original description, by Professor Zeller, is not accessible to me at present, but it will suffice to note the following characters:

Palpi and tuft of the head rich ferruginous, antennæ scarcely half the length of the wing, fine, gray brown. Thoracic tuft dark brown. Wing expanse from 15 to 16^{mm}—rather more than a half-inch. Ground color of primaries somewhat mottled dark brown, with a slight suffusion of olive, diversified by three broad, indistinct, irregular, obliquely transverse bands of purplish gray, having a somewhat metallic reflection; these transverse bands broaden toward the inner margin, where they almost coalesce. On the costal edge is a large, milk-white, rounded triangular or nearly semicircular patch, extending along the costa from the middle third, inclusive, almost to the apex, constituting a most distinguishing and ornamental character. Cilia purplish gray. Secondaries, silky, pale brown with lighter fringes. Abdomen and legs pale brown. Under side of wings pale, rosy brown, the large costal spots on this side inclining to orange.

PROTEOPTERYX SPOLIANA Clem.—The larva folds and webs into clusters the young leaves of apple during the month of May, appearing, preferably, on the shoots of small trees.

Larva.—When full grown it measures 10^{mm} in length by 2½^{mm} in diameter, the form being rather thick cylindrical; color translucent white, tinged with yellowish green; surface velvety; piliferous plates small, glassy, giving rise to short, fine, light hairs. Head and cervical collar same color as general surface or a little deeper in shade, inclining to amber. The head is broad and flat, with red-brown trophi, and a very large dark brown spot on each side. Legs and prolegs same color as general surface.

When full grown it forms a tough, oval cocoon, thickly covered with particles of soil, on the surface of the ground, occasionally just beneath it. It is but single-brooded, and is very difficult to rear in confinement, as it must be kept through the heat of summer and the cold of winter, and if a little too damp it molds, while if moisture is withheld it dries up. From almost innumerable larvæ collected during several years I have only been successful in rearing two or three specimens, enough, however, to determine the species, and, as the moths are always abundant early in the spring on the trunks of orchard and forest trees, there need be no scarcity of specimens for the cabinet:

Adult.—The moth expands 15^{mm}, wings rather narrow. In color it closely simulates the bark of the trees on which it naturally rests. The vestiture of the head is brown interspersed with gray; palpi and antennæ cinereous; thorax and abdomen pale brown. Primaries brown, with a series of oblique double silvery streaks all along the costal edge, extending about one-fourth across the wing; a large silvery spot of irregular outline, inclosing a patch of dark brown, is situated near the outer edge of the wing, and a less distinct patch of silvery scales occurs on the inner edge near the middle, while a shading of the same color modifies the brown tint on other portions of the wing. Cilia pale brown and cinereous intermixed. Secondaries cinereous, shading on costal edge to pale brown; cilia dingy white. There is some variation in distinctness of the markings and depth of coloring.

STEGANOPTYCHA PYRICOLANA Riley MS.—This is somewhat similar to the above in coloring, but smaller and proportionally broader winged. This bores the shoots of the second growth of apple in August and September, occasionally on recently planted trees, inflicting serious damage. The larva spins scarcely any web, but bores downward through the terminal bud, entering the stem for from half an inch to an inch, sometimes blackening all the growing points of a young tree.

Larva.—When full grown it is 8^{mm} long by 1½^{mm} in diameter, slender, subcylindrical, tapering slightly in both directions from middle segments; surface smooth; incisions deep; color, pale cream yellow, somewhat translucent; the dorsal surface beautifully mottled with rose red. Piliferous warts and hairs only discernible with a lens. Ventral surface pale, slightly concave, and much wrinkled. Head elongate, cordate, pale brown, shading to dark brown on the middle of each lobe; trophi prominent, dark brown, with two or three long light hairs on each side. Supra-anal plate oblong, large, dark, smoky brown. Legs and prolegs rather unusually developed.

I failed to rear the first specimens collected, most of them wandering around in the jar until they died. Subsequently, by supplying them with bits of pith or bark in which to bore, I succeeded in getting three or four imagos between the last of September and the first of October.

The moth expands 19^{mm}. The head, thorax, and abdomen are densely covered with long hair-like scales, of a dull gray-brown color with bluish reflections. Basal half of primaries of similar color, but with more intermingling of blue and brown scales. About the middle the wing is crossed by a broad, irregularly outlined band of rich brown, sparsely intermingled with silvery scales, and the terminal third is quite evenly mottled in brown and leaden gray, the costal edge of this portion being ornamented with alternate oblique light and dark streaks extending about one-fourth across the wing; cilia bluish gray; secondaries lustrous pale brown, shading to cinereous on costal edge; cilia dingy white.

Professor Fernald, to whom a specimen was shown, considers it identical with Clemens's *S. salicicolana*, which I believe breeds in willow galls, but Dr. Riley pronounces it distinct, and he has types of Clemens's species.

GELECHIA INTERMEDIELLA? Chambers.—This pretty Tineid appears in its larval form on the tender leaves of apple early in May and again in September. It gnaws the parenchyma from the upper surface, giving the leaves a burned and eroded appearance.

Larva.—8^{mm} in length when mature, slender, cylindrical, tapering slightly in both directions from middle; incisions deep, giving it a submoniliform appearance. General color bluish green, acquiring a purple hue at maturity, with faint longitudinal stripes of cream white. Head pale brown with a tinge of green, ornamented with cream-colored markings on each side and a row of graduated cream-colored dots down the middle of the face. First segment narrow, without perceptible shield. Thoracic legs long, whitish, proceeding from papillated projections on the ventral surface.

This larva covers the leaves with fine web, in which it moves with great agility, and in which it rests suspended, without touching the surface of the leaf, except when feeding. It is semigregarious and very irregular in its development, some clusters of the leaves showing very recently hatched young, while on other clusters they will be full grown. It pupates on surface of the leaf under a little round cover of dense web, similar to those under which some spiders protect their eggs. The moths emerge in about 3 weeks after pupation and hibernate in the perfect state.

Adult.—A beautiful species, expanding 12 or 13^{mm}. Head and thorax dark gray, more or less suffused with crimson; palpi dark gray, annulated with rosy white or pale pink. Ground color of primaries leaden gray and rosy white; scales about evenly intermixed. Three very irregular and variable, often interrupted, bands of rich olive brown cross the wing, intermingled with some light golden brown or ochreous scales; near the base and center of the wing these form quite distinct patches. The apical third of the wing is margined with alternate dark brown and rosy patches; cilia gray. Secondaries cinereous, with paler cilia. This species is closely allied to both *roscofufusella* Clem., and *rubensella* Cham., resembling in coloration the latter and in size the former. Mr. Chambers says of it: "Intermediate between *roscofufusella* Clem., and *rubensella* Cham., with one or the other of which it has hitherto been confounded. The third joint of the palpi is longer and more acute than in *rubensella*, more like that of *roscofufusella*, but the fore wings are much less roseate than in either of the two other species, frequently showing no tinge of the roseate hue. * * * As in *rubensella* (and sometimes in *roscofufusella*), the first dark band does not cover the base of the wing. The second band is like that of *roscofufusella*, but the third extends across the wing, the dorsal portion being, however, paler than the costal, and the costo-apical part of the wing is ochreo-fuscous.

This description, or rather these distinctions, of Mr. Chambers apply to some examples, while to others they do not. Many specimens are very roseate and richly colored, while a few appear almost plain black and dull white. The three species are best distinguished in the larva state, in which there are very decided differences. *G. roseosuffusella* feeds on Clover, *G. rubensella* on Oak, while the species under consideration, so far as my observations show, is confined to Apple. The larval characters are also very diverse in the three species.

EXPERIMENTS WITH INSECTICIDES.

During the great prevalence of *Aphididae* in the spring I made much use of pyrethrum and of the X. O. dust. Of the value of the former as a remedy for these pests, except in the case of one or two species, I have no occasion to change the favorable opinions already repeatedly published. The X. O. dust was thoroughly tested on the following Aphids: *Aphis mali* and *Schizoneura lanigera* on Apple; *Aphis prunifolii* on Plum; *Siphonophora rose* on Rose; *Myzus persicae* on Peach; *Aphis brassicae* on Cabbage; *Aphis* sp.? on Cucumbers and Squash; *Siphonophora* sp.? on Lettuce; *S. cratagi* on Thorns; *S. rudbeckiae* on Solidago; *Aphis ambrosiae* on *Ambrosia trifida*, and *Aphis chrysanthemi*? on Chrysanthemum. With its effects on all of these I was well satisfied, although in some cases it took several dustings to thoroughly clear a plant. When applied with a powder bellows it causes the insects to drop to the ground at once, where they may be pressed into the soil with the foot or patted down with a trowel. The more delicate species succumb to a single thorough dusting and never recover from the effects of contact with the powder. This preparation will also destroy *Siphonophora avenae*, but whether it could in any way be applied to a field of infested grain has not been demonstrated.

The Black Chrysanthemum Aphis is one of the greatest pests of the flower garden and gives much trouble to both amateurs and professional florists. It hibernates on the plant and attacks the stolons as soon as they appear in the spring, and unless great care is taken to eradicate it, it is more or less numerous on the plants throughout the summer, dwarfing and deforming them by its punctures and by the loss of sap which it appropriates. As soon as the buds are formed it seems to develop with four-fold fecundity and requires assiduous attention to keep in check. The Buhach or pyrethrum powder is utterly useless against this species, probably because the plant from which it is made is so close an ally of the Chrysanthemum. The X. O. dust, composed of creosote and tobacco, is the best remedy within my knowledge, killing the Aphis without the slightest injury to the plant. I have found it best to apply during the middle of the day when the dew is off. A few minutes after dusting the plants, I pass along the rows or among the pots, and give each branch a smart shake or a blast of air from the empty puff, and every Aphis that has not previously dropped is dis-

lodged, and "to make assurance doubly sure," it is stamped into the earth. On most of the insect foes of the plant lice the dust produced no disastrous effect, but the larvæ of Syrphidae would, in some cases, not recover from the pungent coating.

Arsenites of ammonia.—This new preparation, for which F. J. Andres, 25 Pearl street, New York, is the agent, was sent to me for experiment, in accordance with directions from the entomologist of the Department of Agriculture. It did not reach me until about the 1st of June, too late for use on a number of insects. It is a clear solution of arsenic in aqua ammonia, and apparently does not differ much from a preparation of my own devising, as reported on two years ago, and with the effects of which on vegetation I was not entirely satisfied. The directions accompanying each of the gallon bottles, in which it is put up, are to use one tablespoonful of the liquid to a gallon of water.

June 7.—Weather clear and hot. Prepared a quantity of the fluid as directed and had it applied to the following plants: To potatoes, on which were a few *Doryphora* larvæ; to rose bushes, on which still lingered a few larvæ of *Selandria rosæ*, *Characlea angulata*, and *Amphipyra pyramidoides*; to cabbage, covered with full-grown and young larvæ of *Pieris rapæ*; to cucumbers and squash infested with *Diabrotica*. It was too late in the season to test it thoroughly on apple for the Codling Moth, and as there were scarcely any peaches or plums or curculios, its effect on the latter insect can not be reported upon. Portions of the trees as well as of cherry were sprayed to discover its effect upon the foliage.

June 9.—Made the rounds of all plants sprayed and noted results as follows:

Potato plants slightly scorched, edges of the leaves curled, larvæ of *Doryphora* mostly on the ground dead, beetles sickly.

Rose bushes uninjured, or very slightly burned where the leaves were very tender; all larvæ killed.

Cabbage uninjured; all *Pieris* and other larvæ killed. Cucumbers much injured, squash less so; striped beetles killed or vanished.

Peach and cherry foliage badly scorched, turned yellow. Plum and apple only slightly injured. Other experiments later in the season made with one tablespoonful of the poison to one and one-half gallons of water were not injurious to any except the most delicate foliage, while in most cases it sufficed to kill *Sphinx quinquemaculata* and *Heliothis armigera* on tomato, *Darapsa myron*, *Cidaria diversilineata*, *Psychomorpha epimenis*, and *De mia maculalis* on grape, with but slight damage to the foliage. The fruit being "bagged" was not touched by it. *Empretia stimulea* on plum and pear and *Datana ministra* on oak also speedily died from eating leaves that had been dampened with it.

I do not consider these experiments conclusive, as with the heat and drought, vegetation was not by any means in a vigorous condition, and therefore more liable to injury from poisonous applications. It is a most convenient preparation and leaves no sediment to disfigure the

foliage, and will, I trust, be found, by more thorough experiment, efficient as an insecticide when used of a strength that will preclude injury to foliage.

Late in the summer a preparation of petroleum sludge with soap was sent me from the New York Chemical Works for trial, but there were very few insects at that time on which to test it, while its almost intolerable and persistent odor is really a serious objection to its use, especially in small gardens.

In making my experiments, I have used the Lewis Combination Force Pump and Syringe, and consider them well adapted for use in small orchards and vineyards, and especially adapted for purposes of experimentation, where the larger and heavier appliances are not necessary.

REPORT ON WORK OF THE SEASON.

By HERBERT OSBORN.

LETTER OF SUBMITTAL.

AMES, IOWA, *October, 1899.*

SIR: I transmit herewith a report upon the work of the season, including mention of certain insects that have been observed during the season and notes regarding certain others, observations on which are in progress, with the expectation of giving more detailed accounts of their life histories and habits.

There is much yet to be done on the insects affecting grass before anything like a full report can be made upon them, but I shall hope to bring the work of the present season into shape for submission at the end of the year.

The work on the parasites of domestic animals has been continued and a part is already submitted for printing, while a considerable amount of other matter is in form to be presented at an early date.

Very respectfully,

HERBERT OSBORN.

Prof. C. V. RILEY,
U. S. Entomologist.

During the past summer there has been no great depredation by any single insect pest in the State, but a number of the common species of insects have been working with their accustomed energy, and the losses from this source in the State have probably been up to the average of ordinary seasons.

The observations on insects affecting grass crops have been continued, and I am only the more strongly impressed with the importance of the insects affecting these crops in this State, and believe that the estimates given in my last year's report as to the probable loss from this source to have been by no means overstated.

Judging by the reports of the correspondents of the Iowa Weather and Crop Service, who represent every section of the State, the insects that have caused most extensive injury are those infesting meadows and pastures and sod land planted to corn. Not only are there numerous reports of injury by insects to timothy, to pastures, and to corn planted on land previously in grass, but numerous mention of poor condition in meadows and pastures, shortage in grass and hay crop,

etc., which, to any one familiar with the great number of insects now infesting grass land in this region, tell a certain story as to at least one of the great sources of loss.

Frequent mention is made of the Cutworms, Grubworms, Wireworms, etc., and it is evident that a very great variety of species are included in this list; but while I am certain that many species of Cutworms belonging to the common species of Noctuidæ are included in this list, I believe that much of this injury is due to the species of Crambus treated in detail in my report for 1887, the Dried Crambus (*Crambus exsiccatu*s), or as called in the larval stage, the Sodworm or Turf Webworm. This has been very plentiful here in the adult form the present season, though by no means so abundant as in 1887, and I have no doubt that it has been as abundant in other parts of the State. The work of this species in meadows, however, would not be readily distinguished from that of Cutworms by those unfamiliar with the habits of insects, and even in corn the effect on the plants is not easily to be distinguished from the effects of Cutworms, Wireworms, or other forms of insects attacking the stalks at or near the surface of the ground.

LEAF HOPPERS IN GRASS.

In my report of last season I mentioned a number of species of leaf hoppers (*Jassidæ*) that are destructive in grass land. Further observation and collection in this same line has served to strengthen my opinion as to the great amount of injury to be attributed to these minute insects. A number of species particularly of the genus *Deltocephalus* occur in immense numbers in grass land, and among the most common of those observed here are the *Deltocephalus (Jassus) inimicus* Say, treated of in last year's report, but associated with these are *D. debilis* Uhler., *D. Sayi* Fitch, *D. Melsheimeri* Fitch, and a number of species apparently as yet undescribed. A fuller report upon these I hope to make a little later when material on hand can be more fully examined and a more complete statement of results given, but it may be in place to mention as one of the results of this study that I have been convinced that these insects are a very important factor in the production of "silver-top" in grass, this being one of the effects produced by their suction of the juices of the plant and resulting when they penetrate the succulent portion of the stem at the base of the terminal node. That other insects may and do cause this same form of withering and injury to grass I do not deny, but in a great number of examinations of injured stems I have in the great majority of cases found no insect within the sheath of the injured part, and feel positive that for these the injury could not have been produced by Thrips or Meromyza or any insect working within the stem while the presence of immense numbers of the leaf hopper on the affected plants and the presence of punctures show clearly the possibility of the injury being due to them.

This question has been more fully discussed in a paper read with your consent before the Association for the Promotion of Agricultural Science at the Indianapolis meeting. In that paper I have referred to different explanations for the silver-topped condition of grass and presented the grounds for my own opinion that for this locality and in blue grass the injury must be referred mainly to these Jassidæ. From the fact that these Jassidæ are exposed to the application of remedies that would not affect insects protected in the sheath it is evident that the adoption of measures to destroy these, as suggested in my last year's report, should result in a decrease of the "silver-top."

GRASSHOPPERS AND CRICKETS IN GRASS.

The common species of grasshoppers or locusts have been as usual very plentiful, *Melanoplus femur-rubrum* probably heading the list for abundance, but several other species, as *M. differentialis*, *Dissosteira carolina*, *Tomonotus sulphureus*, and *Arphia sordida* form a very conspicuous part of the grass-eating species. For the present season also there has been a very great abundance of the little field cricket, *Nemobius vittatus*. This was noticed as especially abundant on sunny hill-sides in pastures and in many places aggregated in such numbers as to completely cover the surface of the ground. While this species has been rather frequently mentioned among the species common throughout the country and its herbivorous habits accepted, so far as I know by all, there has been apparently little attention to it as a destructive species or one worthy of particular attention on account of the injury it may cause in pastures.

It is quite evident, however, that when occurring in anything like the abundance in which it has been observed here this season it must be the cause of no little loss, and it may very well be associated with the more frequently mentioned locusts in the category of destructive meadow insects.

MISCELLANEOUS NOTES.

The Apple Leaf Skeletonizer (*Pempelia hammondii*) has been sent me this season from near Des Moines, where it was reported as doing considerable damage. This insect has been comparatively rare in the State for a number of years, but from the account received of its appearance this year it must have been in such numbers as to cause no little damage, and it is to be hoped that prompt measures will be adopted by the fruit-growers of that locality to prevent its spread.

The Turnus Butterfly (*Papilio turnus*) has been noticed as more than ordinarily abundant, the larvæ occurring in considerable numbers on various trees, especially on plum trees in this vicinity. While the species has seldom assumed an economic importance, in this State at least, it may be that it will require occasional attention, and it will of course readily succumb to the treatment by spraying, so efficacious for leaf-eating larvæ.

The Cherry Slug (*Selandria cerasi*) has also been quite plentiful and damaging cherry and plum trees. It would appear that this insect has been rather more than usually common in a considerable territory the present season, as I have heard of it from various localities. It is generally the case, however, that it does little damage for more than one or two seasons in succession, so that it seems hardly necessary to take any great amount of trouble in dealing with it unless it is working destructively upon particular trees, when the usual poisonous sprays suffice to rid the trees of its presence.

The Handmaid Moth (*Datana ministra*) has been on the increase apparently for a number of years past and for the last two years has succeeded in defoliating quite a number of trees in the vicinity, especially hickories and black walnuts. As mentioned in another place, the arsenite of ammonia was used in treating it this fall and proved very efficient in destroying the insects. Previously, we have used London purple for this purpose, and there is apparently little choice, unless there be sufficient difference in price to render one cheaper than the other. It is important in using any of the poisonous solutions for this species to spray the whole tree or as much of it as possible, since when only the part where the worms may be working at any particular time is sprayed, they are very likely in their next move to occupy some part where there is no poison to affect them, and they may in this way escape until they have caused considerable damage to the tree.

Abbot's White Pine Worm (*Lophyrus abbotii*) has appeared in the State, and so far as I am aware it is the first time that this destructive insect has been brought to notice in Iowa. It was sent to me from Farley and with the report that the evergreen trees were suffering severely from its attacks.

The Corn Root Worm (*Diabrotica longicornis*) is evidently on the increase and gradually extending throughout such localities as it has not hitherto occupied. Here, it appears very abundantly in the adult stage, and in fall, collecting in great numbers on flowers. So far as I know there has not as yet been any very great injury to the corn in the vicinity, but probably the worms occur in considerable numbers scattered through the various fields, and it is probable that in a short time they will multiply to such an extent that in fields kept long in corn they will cause serious loss.

The species of *Diabrotica* infesting squashes, melons, etc., *D. vittata* and *D. punctata*, have been very abundant the past season, though perhaps not more so than is common for them, but the crops they infest have required attention in order to prevent serious loss.

The Potato Stalk Weevil (*Trichobaris trinotatus*) was observed this season for the first time and occurred in such numbers as to cause considerable damage. It was first noticed by Mr. F. A. Sirrine, a special student in entomology, at present assisting in the botanical work in the Experiment Station. It is quite likely that the insect has been present

in previous seasons in small numbers, but it has not been taken even in the adult form, in this locality till this summer, so that it seems more likely that it has been introduced in some way quite recently.

TESTS OF ARSENITE OF AMMONIA.

During the month of May I received instructions from Mr. Howard to make tests of an insecticide put on the market by Fr. Jac. Andres, of 25 Pearl street, New York, under the name of arsenite of ammonia, as agent for the Caspar Schneider Chemical Works. In due time the samples came from the New York firm and I proceeded to make such tests as were possible to determine both the effects upon various kinds of plants and its effectiveness in killing insects.

On the morning of May 30, 1890, between 9 and 10 o'clock of a hot, sunny day, I sprayed the following plants with a view to giving a thorough test of the effect on foliage:

Squash vines infested with *Diabrotica vittata*.

Cucumber vines infested with *Diabrotica vittata*.

Potato vines infested with *Epitrix cucumeris*.

Plum, Cherry, Box-elder, Willow, Elæagnus, Elm, Mountain Ash, Birch, Apple, Raspberry, beans, grass, and clover.

The results were watched closely for a number of days but the record of June 2 gives the results for the entire set. On that day a careful examination was made of all the plants that had been treated and it was found that in no case could there be found any injury to the foliage, except possibly a slight injury to the elm and the beans, but the injury was so slight, if any, in these cases that it could hardly be charged with certainty against the arsenite. The solution in this case was as given in the directions, a tablespoonful to an ordinary pailful of water, and the conclusion was that with this strength it could be applied without danger to any of the above-named plants.

On the squash vines and cucumber vines the beetles seemed much less abundant, but I was unable to find any dead insects around the vines. The hills treated, however, remained quite free from further trouble from these insects, while others in the vicinity were seriously affected. The failure to find dead beetles under the treated plants might easily result from the insects flying away after eating the poison to places of shelter and dying there. The same was true of the flea-beetle affecting potatoes. The beetles seemed much less abundant, but no dead ones could be found under the treated vines.

While it was so late in the season that it was not expected that this test would give any definite results as to the effect on the codling moth, it is worthy of mention that the branches of the apple tree sprayed with the arsenite were loaded with apples, while the other portions of the tree were much less fully loaded.

The apples also of this portion were quite free from worms, though in the late fall they were of course exposed to the action of the second

brood and a portion of the fruit was found infested. While this is not given as a good example of the effect of spraying, it seems strong enough certainly to warrant the conclusion that the arsenite of ammonia will prove as effectual as any other form of the poison against this pest.

There were none of the Colorado Potato Beetles to be found in the vicinity, so the poison could not be tested with them, a test that would have been of course more satisfactory, especially with the larvæ, because of the fact that the dead insects can afterward be found readily around the treated vines.

I was able, however, to give a thorough trial of the insecticide properties of the substance later in the season on the common Handmaid Moth (*Datana ministra*), which was very plentiful on some of the hickory and black walnut trees in the vicinity. A single application of the poison was found to kill the caterpillars in large numbers, evidently affecting all that fed upon the leaves that had been reached by the poison. Dead caterpillars began to be found in 24 hours from time of application, and for two or three days afterward the caterpillars were dying off rapidly. The application was in this case made a little stronger than in the first trials, and in a few days the trees showed some injury from the effects of the arsenite, so it seems quite evident that the strength for these trees must be kept within the limits indicated by the directions. The liquid is very convenient to mix with water, and forms probably a very uniform mixture, so that it seems to possess some points of superiority ver the arsenites in solid form.

REPORT ON SOME OF THE INSECTS AFFECTING CEREAL CROPS.

By F. M. WEBSTER.

LETTER OF SUBMITTAL.

LA FAYETTE, IND., *October 22, 1890.*

SIR: I herewith submit my annual report of observations on some of the insects affecting cereal grains. For assistance in carrying on the experiments connected with the studies of the Hessian Fly, I am greatly indebted to the following gentlemen: Hon. Samuel Hargrave, Princeton; Mr. W. S. Ratliff, Richmond; Mr. Miles Martin, Marshall; Hon. W. Banks, La Porte, and Hon. J. N. Lakta, Hawpatch; to Purdue University, and later the experiment station. I am also under obligations for use of land, seed, and labor in carrying out my own experiments here at La Fayette.

To yourself especially, and others of the division, I am under many obligations for the determination of specimens and other numberless favors.

Respectfully submitted.

F. M. WEBSTER.

Dr. C. V. RILEY,
U. S. Entomologist.

THE HESSIAN FLY.

Number and Development of Broods.

My experiments, notes, and observations upon this insect extend over a period of a little over six years, and while it received little more attention than was given other wheat-destroying species, a considerable number of facts have accumulated which, while not by any means clearing up all of the mysteries of the pest, will nevertheless serve to throw some light on several obscure points. Unless otherwise stated, all of my observations and experiments herein recorded relate to the State of Indiana, extending from latitude $37^{\circ} 50'$ to about $41^{\circ} 45' N$. The exact latitude of many places of observation is given, not so much for the American reader or investigator as for those of other countries, notably England and Russia.

My experiments and observations have been carried on almost exclusively out of doors and very largely in the fields, as I consider indoor and breeding-cage observations on this species, except for the purpose

of securing specimens and parasites, of very doubtful value from an economic standpoint or as indicating its normal habits. The observations have many of them been once and often twice substantiated.

In ordinary seasons and throughout the area above indicated the statement made long ago by Dr. Fitch that the Hessian Fly is double brooded is true. While in the southern portion of the State the fall brood of adults seem to appear some weeks later than in the northern part, nevertheless I have found but two destructive broods. Between these two broods, however, is a considerable mass of fluctuating individuals, the true position of which is rather anomalous.*

At LaFayette, Ind., latitude $40^{\circ} 27'$, wheat plants were transferred from the fields to the breeding cages April 5, 1890, and kept out of doors. The seed producing these plants had been sown the preceding September 3. On April 17 a female emerged, and a male appearing soon after, these, on April 22, were both placed together on young growing wheat planted in a breeding cage, out of doors. From these adults were secured June 8. The attempt was made to follow the offspring of these, but failed on account of the wheat being killed by rust. On June 7, and also on the 14th, 1888, in the same locality, adults were observed ovipositing, the eggs being placed on the youngest and most tender shoots, and there was every evidence that these eggs developed through the larval to the flaxseed stage by early July. Besides, I have observed in the same locality late-growing shoots literally overrun with very young larvæ on the 26th of June, and found larvæ as late as the 10th of July.

On October 16, 1887, Mr. W. S. Ratliff, who made a great number of experiments for me, near Richmond, Ind. (latitude $30^{\circ} 51'$), secured adults from a small plot of wheat plants which appeared above the ground September 4. From a plant from this same plot that had been transplanted indoors, he secured an adult female 11 days earlier. In either of these cases with favorable weather the female could have sent her offspring into the winter in the flaxseed state. Mr. Ratliff also observed adults on July 10, 1887. At La Fayette, Ind., the same autumn, I saw females ovipositing on November 3, in a temperature of 64° F., among the plants. From a plot sown August 13, and which came up on the 17th, I obtained adults of both sexes on October 1, 44 days after the plants appeared and 48 days after sowing. That larvæ, even though quite immature when winter begins, may survive till spring has been demonstrated again and again, and was especially true of the exceedingly mild winter of 1889-90. In fact, by a series of sowings all

* Dr. Fitch states that the eggs of the fall brood are deposited in the State of New York early in September, and also that "the deposit is doubtless made later to the south of us than it is here in New York." (*Seventh Report*.) Mr. Edward Tilghman observed oviposition in Queen Anne's County, Maryland, about latitude 39° to $39^{\circ} 30'$, during the second week in October, and mentions it as of usual occurrence. (*The Cultivator*, May, 1841.)

stages of the insect can be produced continually from April to October, and by keeping a cage indoors I have produced adults in abundance in January.

As Dr. Lindeman has well stated, the puparia are greatly influenced by environment, temperature, etc., and this is probably true of the other stages, larvæ of different ages being, for all we know, influenced to a different degree. To these facts must be added another of considerable moment, viz, while nominally two brooded, flaxseeds collected by me in the spring of one year have lived over to the spring of the following year. This is also true of at least one of the parasites of the species. How far the number of these interlopers is augmented by a retarded development of greater or less extent it is impossible to say, but that there is an accession through this means there can be no doubt. In fact, it would appear as though nature had in this way provided against the extinction of the species.

Now, is it proper for us, from these scattering individuals, to attempt to construct distinct broods? It seems to me not. I have several times sown wheat at La Fayette early in July and never had it seriously infested by Hessian fly until late in August or early in September. Very young larvæ were exceedingly abundant early in October of this year in a field of early-sown wheat near La Fayette.

It is true that observations during a single season, in a single locality, might produce apparently good evidence of a third brood, but a continued close study of the species in such locality will probably show it unfounded. That these aberrant individuals may, under favorable conditions, collect or "bunch" together in certain fields is probably true, but my own experience has been that the following year this irregularity will have disappeared or have been reduced to a minimum by the effect of the weather during midsummer and winter. On June 24, 1887, near Princeton, Indiana, latitude $38^{\circ} 23' N.$, I found a field of wheat, sown about the first of the preceding November, literally alive with larvæ from one-fourth to nearly or quite full grown. There were no pupæ to speak of in this field at the time, but in other fields in the vicinity these were abundant, but here there was no larvæ to be found. At this date wheat harvest was at its height. The late-sown field had evidently attracted the late-appearing adults of the fall before, and their progeny, living over in this field, as delayed larvæ, emerged correspondingly late in the spring, giving rise to the generation of larvæ observed by me. My reason for taking this view is that I have several times tried to draw off the spring brood of flies by offering them young plants on which to oviposit, but have always failed, as they seemed to prefer tender shoots of older plants to the young plants themselves. In the fall this characteristic seems to be somewhat the reverse, although even then, if attacked after tillering, the tillers will be chosen instead of the main stem. The fall brood of adults is probably the migratory brood, and their power of detecting wheat plants is almost phenomenal.

I have drawn them to a small plat of wheat sown in a secluded corner of my garden, in the midst of town, fully half a mile from any wheat fields. But, be this as it may, a second brood of larvæ in June would be rather difficult to sustain, as the puparia of the earlier part of the month are known to remain in that stage until September. Neither have I been able to secure any better evidence of a brood originating in volunteer wheat during July and August. Puparia are to be found every year from one end of the State to the other in this volunteer wheat, but here in Indiana I have never found these sufficiently numerous to imply a distinct brood. Professor Forbes and his assistants, working in Illinois, appear to have a greater confidence in this extra brood than myself, although, as will appear farther on, our experiments were carried on the one perfectly independent of the other, though only a few miles apart.

My attention has been called to the condition of this field near Princeton, by Honorable Samuel Hargrove, member of the board of trustees of Purdue University, and also a member of the State Board of Agriculture, who willingly agreed to further aid in the investigations by sowing for me plats of wheat at intervals of about 2 weeks, beginning as soon as possible after harvest. Being detained in Louisiana myself until nearly the 1st of August, and the weather being exceedingly dry, no plats were sown until August 4, 1887, followed by another on August 22, and a third September 5. These were sown on one of Mr. Hargrove's farms, about 10 miles northeast of Princeton.

The first two sowings, owing to the drought, came up sparingly and about the same time. The third was also affected by drought, and did not come up until about the 1st of October. These plats were sown along the lower edge of a high, rolling stubble field, which had been too dry to plow, and in which I had found an abundance of flaxseeds the preceding June.

These plats were examined by me on October 8. The two earlier-sown plats had thrown up a good growth of plants, which had tillered finely, being along a low ravine. On these plats I found a number of larvæ, which were nearly or quite grown, and a less number of flaxseeds, one of which was empty. Besides these, the plants were literally alive with very young larvæ, so young, in fact, that they had not yet lost their reddish tint. The third plat had sent up the normal number of plants, which were now in the second leaf. These plants had not appeared in time for the earlier deposited eggs, but were even more seriously infested by young larvæ than the plants of the two earlier plats. One of the plants from the last plat is before me, and contains twenty-six young larvæ, all of which must have hatched from the eggs only a few days prior to my observations. Now, from whence did the progenitors of these young larvæ originate? Most assuredly not from volunteer wheat, because there was none. Not from my earlier-sown plats, else these would have shown the effect. There are, it seems to me, but two

other sources from which they could have come, viz, the stubble, which I know to have been infested, and grasses, which we have no knowledge of the species affecting.

These plats were plowed up soon after examination, as I was afraid to allow them to stand thus, a menace to the adjoining fields the following spring, though the plants would have probably been destroyed before even a small portion of the larvæ matured.

From all the information that I am able to gather, the usual time of appearance of the fall brood of adult flies in southern Indiana is the last portion of September, or some years the first days of October. This is, I believe, the opinion of the most observing farmers, including Hon. J. Q. A. Seig, of Corydon, Harrison County, who is as familiar with the earlier stages of the pest and its effect upon fall wheat as I am myself. Mr. J. P. Londen, of Sharp's Mills, same county, stated that wheat sown on October 1, 1886, was damaged 50 per cent., while that sown on the 6th was injured only 15 per cent. Mr. J. A. Burton, writing from Mitchell, Lawrence County, November 24, 1887, gave the results of his examination of wheatfields as follows: Fields sown September 8, about one plant in 8 infested; sown September 15, about one plant in 12; sown September 22, about one plant in 50, and sown October 1, seemingly free from injury. The observations of these gentlemen also coincide with my own, made in November, 1888, in Harrison and Posey Counties. Therefore, from all the information which I have been able to gain, the best season for wheat sowing, to avoid the attacks of the Hessian fly in extreme southern Indiana, is soon after the 1st of October. Exactly how far northward this advice will apply I am unable to say, but am inclined to think it would cover territory laying between latitude 38° and 39° , and possibly $39^{\circ} 30'$, although near the northern limit it would probably be safe during ordinary years to sow soon after September 25.

During the years 1887 and 1888 Mr. W. S. Ratliff made a large number of very careful observations, and sowed a series of plats of wheat on different dates near Richmond, Ind. In 1887 plats were sown August 5 and 29, September 12 and 26. All of these plats were attacked and more or less injured except the last, which as late as December 19 showed not the least injury by the Hessian fly. Up to May 31, 1888, there was very little injury to this plat, and even on the above date there were very few larvæ as compared with the number on the others. From this date on till July 11 the plats were all injured by black and red rusts, Chinch bugs, and the Wheat Stem maggot, the greater injury appearing to fall upon this, so that at harvest, July 11, the last was the poorest of all in yield, that sown August 15 being the best. The sowings of 1888 were as follows: September 6, 20; October 4, 22; November 1. On November 14 the first plat was found to be infested by larvæ of the Hessian fly. During June, 1889, Chinch bugs again attacked the plants growing on these plats, and the grain aphid seriously

injured the later sown plats, so that at harvest, July 5, these latter were the poorest of all, the other three averaging about alike. All of these plats during both years had been sown in narrow strips among corn along one side, the remainder of the field being corn, and later also sown to wheat, thus bringing the latest-sown plats between those sown earliest and the entire field itself, as appeared to me, the severest test to which I could subject the several plats. The results, while not conclusive or even entirely satisfactory, indicate that in that latitude about September 25 is, generally speaking, a good time to sow wheat to escape fall attacks of the fly and winter killing. A series of plats sown for me by Mr. Miles Martin, of Marshall, Parke County, Ind., in very near the same latitude as Richmond, but nearer the western border of the State, gave rather more conclusive results, the sowings of September 22 being almost entirely exempt from the attack of the Hessian fly, while earlier plats were infested.

In regard to my own experiments here on the Experiment Station grounds at Lafayette, I may state that I have never been able to provoke a disastrous attack of the pest, though there has been nothing left undone which could possibly induce the adult flies to oviposit at any time between March and December; and there is probably not a month between these dates during which the insect could not have been found in all of its stages. The two destructive broods, however, invariably appear in May and September; in the latter case usually before the 20th.

My own experimental showings were rather more elaborate and extensive than those of any of my correspondents, comprising a number of varieties and extending over several months. Without going into details, the experiments and results may be summarized as follows: 1887, plats comprising the varieties Michigan Amber, Clawson and Velvet Chaff, each one width of a grain drill twenty rods in length, were sown on the following dates: August 13, 27; September 10, 24; October 8, 27; November 5, 19. The autumn was very dry, and the plants of the first six plats went into winter in poor condition, being very small, while the last two sowings did not come up until the following spring. The severe winter destroyed the plants so generally, that only the first three produced sufficient grain to pay for harvesting. These were also the only ones to suffer from the fall attack of the fly, the first producing adults October 1. Plat 8 was attacked on the following June, and on the 26th was badly infested with young larvæ, full-grown larvæ and puparia, the latter, the most numerous, were found on the 16th of July. The plats harvested produced a poor crop, but the Michigan Amber ranked first, Velvet Chaff second, and Clawson the poorest of all.

The condition of the Hessian fly in these three plats, at the time of harvest, July 10, 1888, may be inferred from the result of examinations made on this date.

Empty flaxseeds	15
Containing healthy pupæ or parasites.....	69
Larvæ	16
Total	100

August 3, the state of the insect in these same plats was as follows :

Empty flaxseeds.....	53
Containing healthy pupæ and parasites.....	47
Total	100

The condition of the insect on September 1, as shown by examination of the stubble, is indicated below :

Empty flaxseeds.....	55
Healthy flaxseeds	28
Parasitized flaxseeds	17
Total.....	100

Notwithstanding the per cent of healthy puparia passing the summer was small, there is little probability that many adult flies emerged. A plat of the same dimensions was sown July 16, along one side of the first three sown the previous fall, the plants of this last sowing coming up ten days later. This plat was closely watched. After July 17 only an occasional larva was found. By August 4 plants had been destroyed by the combined influences of chinch bugs and dry weather, but a second plat has been sown adjoining, and the plants of this appeared above ground on August 6. On September 4, 200 plants were examined and but two larvæ were found thereon. A second examination of the same number of plants from this plat, on September 15, revealed a small number of young larvæ. A third examination of this plat on October 6 showed about 1 per cent of the plants to be infested. Stubble from the three original plats, kept in breeding cages, out of doors, did not give adults until the 17th of September, although it is quite probable that some few were abroad before that date. It will be seen, however, that no great number could have emerged from the stubble, and the increase in the number of empty flaxseeds between July 10 and September 1 is doubtless to be attributed to parasites. This appears all the more probable, as I have repeatedly observed these parasites during July and August emerge in breeding cages, and at once begin to oviposit in flaxseed in the stubble from which they had themselves emerged. The percentage of healthy puparia reaching September in safety, however, was probably unusually small, as experiments on the same ground the following year did not suffer near so much from either fall or spring attacks. Another feature of these experiments is, that it strongly indicates that the larger per cent of the parasites emerge prior to the 1st of August. Indeed, stubble from the entire length of

the State, collected in June and placed in breeding out of doors here at La Fayette, has indicated the truth of this.

The sowings of 1888 were made on August 30, September 18, October 3, 6. Of these, only the first sown were attacked in the fall, that sown on September 18 being in the best condition the following July. During May, 1889, the plants of these plats were found to be much less infested than some fields a considerable distance away, although such fields had been sown on oats stubble, while the ground on which my experiments were located was the same that had been used for this purpose the previous year.

The sowings of 1889 were continued on the same grounds, the plats being sown September 3-20, October 4-18, November 4. The autumn attack was the most severe on the first plat, but the extremely mild fall and winter was so favorable to the development of the flies that the spring attack was unusually severe, and appeared to fall upon the three earlier sown plats with about equal force. The later sown plats, though the plants were much the younger, did not suffer so much, but these were very seriously affected by the weather during early spring.

These experiments appeared to indicate that, in this latitude, while wheat sown as early as the last of August may under favorable conditions and during particular seasons produce as good or even a better crop than when sown at a later date, yet such cases are the exception and not the rule; but that wheat sown as soon as possible after the 20th of September stands the best chance of evading the attacks of the fly and withstanding the unfavorable weather, the regular operations of the University farm during the last seven years certainly substantiate. It is the custom with the experiment farm, each year, to sow the regular field crop at this time, and in no case has severe injury been sustained from attacks of the Hessian fly. Fields on adjoining farms sown at earlier dates have frequently been seriously injured, although this has not invariably followed.

Another series of experimental sowings was carried on for me by Hon. W. A. Banks, near La Porte, Ind., about latitude $41^{\circ} 35'$. The first series of these sowings was begun in August of 1887. The sowings of 1888 were not carried on under Mr. Banks's immediate supervision, and were of little value. No experiments were made in 1889, but a well planned and carefully executed series were sown in the fall of 1890. The series of 1887, each of which comprised two widths of a grain drill, extended along one side of the field about 60 rods in length, the first of which was sown on August 13, the plants appearing above ground within a few days. The second sowing was on August 23, a third on September 2, the fourth September 12, the fifth September 22, the sixth and last on October 7. These plats were visited by me on October 14, and their condition found to be as follows: The first was found to be infested by great numbers of larvæ and puparia, some of the shells of the latter being empty, and the plants were seriously dam-

aged. The second plat was even worse injured than the first, and the third much worse than either of the others. The fourth appeared to be almost as badly infested as the third, but it had only partly tillered, and hence there was a better prospect for it to throw up unaffected shoots. The fifth had not tillered, and was only very slightly infested, with very young larvæ, while the sixth was not yet up.

On April 12, 1888, the plats were visited again. About 25 per cent of the plants on the first three plats appeared to have survived. The fourth was apparently 50 per cent better, the fifth was in almost as good shape as the fourth, while the sixth was backward, the plants being small and thin on the ground.

The estimate yield, made by Mr. Banks at time of harvest, on the basis of 20 bushels per acre as an average yield, was as follows: First plat, 50 per cent; second, 50 per cent; third, 65 per cent; fourth, 90 per cent; fifth, 70 per cent. The remainder of the field was sown on September 2, and shared in the destruction in common with plat 3. Another field at some distance from this was sown about September 20 and sustained no material injury.

It will be observed that the first three plats were sown almost at the same time as the first three at La Fayette, yet stubble from the first three plats at La Porte, collected on September 2 and placed in a breeding cage beside another containing stubble from the first three at La Fayette, gave adult flies nearly a week earlier. In other words, the majority of the adults from Mr. Banks's plats emerged prior to September 15, while those from my own did not reach their maximum numbers until after the 15th, and from then on till the 25th. In both cases, however, a few stragglers emerged occasionally until early in October. As previously stated, the plats of 1888 were not properly sown, Mr. Banks not being able to attend to them himself; but a visit to the locality on November 8 revealed but very little injury to wheat which had been sown after the middle of September.

The experiment plats of 1890 were sown September 1, 10, 20, 30. These were examined late in October and fully substantiated the experiments of previous years. The sowing of September 1 was considerably injured, while that of the 10th was very seriously affected, as was also a large field adjoining sown but a day or two later. The sowing of September 20 was comparatively free from attack, while that sown September 30 appeared to have almost entirely escaped injury.

The sixth and last series of experiments were made for me by Hon. J. N. Latta, at Haw Patch, Lagrange County, in about the same latitude as La Porte. The sowings were made in 1887, the first being drilled on July 28, but owing to drought the plants did not appear above ground until about the 28th of August. The second plat was sown on August 15, but came up the same time as the first; the third, sown September 1, came up September 6; the fourth, sown September 12, came up September 21; the fifth, sown September 24, came up the

28; while the sixth and last was sown October 12, and did not come up until about the 20th. These plats were examined by me on October 17; the first three and the last sown were very poor, the fourth and fifth promising a fair yield. A field adjoining, sown on the same day as plat 5, did not suffer from the fly and produced nearly an average yield of 20 bushels per acre.

The results of these meager experiments have, as a rule, proven correct in the fields of the farmers. I have not only observed this myself, but it has become well known in the locality that wheat sown before September 15 and after the 30th of the same month seldom produces a good crop, while that sown between the 15th and the 25th is the most likely to escape the attack of the Hessian fly, and, as a general thing winters, as well as that sown earlier.

In summing up the results of this entire system of experiments, it seems that while no exact date can be laid down for the appearing of the fall brood of fly in any precise locality, there is, notwithstanding, a gradual delay in its appearance as we go from the north southward. In other words, there is here a characteristic element in the life history of the species which may be utilized by the farmer to his advantage. Fruit-growers, I believe, estimate that in spring the season advances northward at the rate of about 12 miles per day. This would be a trifle less than 6 days per degree of latitude. If farmers in extreme northern Indiana and southern Michigan can sow their wheat with safety about the 12th to the 15th of September (and we have demonstrated that the fall brood emerges largely prior to the 15th), and farmers in extreme southern Indiana must delay sowing until after the first days of October, there must be a general system of retardation, which, if understood, may be used to advantage throughout the intervening territory.

Starting in southern Michigan on the 12th to 15th and passing 4 degrees south to the vicinity of Evansville, Ind., we should expect about the same condition of the Hessian fly during the first week of October. That is, if we pass the danger line about the second week of September in southern Michigan, we should expect to encounter it again in southern Indiana in the first or second week of October. A considerable correspondence and my own experiments indicate that this is usually true. It is not to be supposed, however, that it is possible for me to give precise dates for given localities, as there is another element which is likely to figure in these calculations, viz, elevation. It has been stated upon reliable authority that "an elevation of 350 feet is equal to 1 degree of cold in the mean annual temperature, or 60 miles on the surface northward."* While we can hardly expect this to influence comparatively level countries like the State of Indiana at least to any marked degree, extensive areas of high table-

* Draper's Intellectual Development of Europe, Harper Bros., New York, revised edition, vol. 1, p. 29.

lands would be apt to show its effect more distinctly. There may also be some obscure influence peculiar to the natures of the different soils.

It will be seen, therefore, that the experiments have fallen far short of settling the whole problem, yet it seems to me that they have been carried as far as profitable, and the matter is now in proper state to be taken up by the intelligent farmer, whose experimental plats are his fields. And it may be added that this is done with a feeling on my part that whatever of truth there may be in the matter will stand as a nucleus about which others may build, while whatever there may be of error will as surely disappear.

THE EFFECT OF THE LARVÆ ON THE PLANTS.

The effect of the larvæ, especially on the young plants, does not appear to be generally understood, and I have myself been able to verify either the figures or descriptions of Fitch and Packard only in exceptional cases. The swollen bulb just above the roots in Fitch's figures gives but a vague idea of the true appearance, while Packard's figure represents plants which have very evidently sprung from seeds only slightly covered by the soil. Besides, the former figure only represents the condition of the plants long after the larvæ have done their work, and the latter, aside from the shoot being shorter, gives no idea of the appearance of an infested stem, as found in nature, growing in the fields. The yellow color of the foliage—there is usually more brown than yellow about it—appears later, after the larvæ are full-fed, and then it is largely, at least, confined to the younger leaves, the older ones, under whose sheaths the larvæ occur, are killed by the freezing weather of winter. In Circular No. 2 of the Agricultural Experiment Station of Purdue University I have given a representation of an infested plant fresh from the field drawn from nature. The plant had been attacked soon after its appearance above ground and had not tillered. The leaves under these conditions are broader, darker green, more vertical and bunchy. The youngest leaf on a healthy plant as it unfolds and pushes upward is of a tubular form and spindle-shaped, somewhat as represented in Packard's figure of a healthy plant. In the case of an affected plant, the stem having been destroyed below ground, the spindle-shaped central leaf is always absent. The difference between a healthy and infested plant is shown by a comparison of figures. If a plant has already tillered, each of the identical laterals, as they are attacked, will begin to take on the form and color above described. It is, therefore, not only possible to detect an infected plant without removing it from the ground, but also to determine the individual tiller infested. Now, while this feature of infested plants is so very clearly marked, at least after the larvæ are one-third grown, and from an economic standpoint of so much importance that it is surprising that it should have been overlooked, yet I can not myself lay claim to the fact by right of discovery, as it was pointed out to me by a farmer in the autumn of 1884, and was

the outcome of circular No. 1, issued in October, 1884, from Purdue University. It was only after testing the stability of this feature in various fields, under widely different conditions, that I placed full reliance upon its permanency. An illustrated circular of inquiry, No. 2, issued by myself from Purdue University during the fall of 1887, brought also a great number of replies, from among which I have selected the two following, because of their widely separated localities and the well-known ability of the writers:

CLYDE, N. Y., *December 9, 1887.*

DEAR SIR: In regard to the appearance of wheat plants infested with Hessian fly, and as illustrated and explained by Fig. 3 of circular, I believe that it is correct in the main, especially the darker color possessed by infected plants over healthy plants, and this is, as you say, quite different from the information given by Fitch and Packard; and you have published this quite constant and true form and condition for the first time, I believe. I had noticed this somewhat a year ago, and in bringing up the destruction done by the Hessian fly in a Grange meeting, I found that a number of farmers reported this very condition, viz: when fields or parts of fields looked extra dark colored and healthy, damage from the fly was to be apprehended there. Still, the yellow color came after a while, especially with early-sown winter wheat in a long autumn or the following spring. I think the spring brood are apt to select tillers.

Truly,

W. L. DEVEREAUX.

Prof. F. M. WEBSTER,
La Fayette, Ind.

UNIVERSITY OF CALIFORNIA, COLLEGE OF AGRICULTURE,

Berkeley, December 15, 1887.

DEAR SIR: Your favor of November 23, with circular relating to appearance of grain infested with Hessian fly, received. The appearances you describe are quite characteristic of fly-infested grain here, but it is not seen in the fall, for we do not have any grain above ground at that time. The districts in which the fly is found in this State are of narrow area comparatively near the coast. In these parts it is not usual to sow grain until after the winter rains have wet the ground enough for plowing, and sowing can some years be made as late as the last of February, and still do well. It is better, however, both for the growth of the grain and baffling of the fly, to sow in January if the soil is in proper condition. For these reasons we do not find the flaxseeds until about the first of March, and then it is that the grain assumes the feature you describe. It is a very bunchy growth, with very few yellow leaves and exceedingly few seed stems thrown out. On some of our plats there will not be a single stem, but the grain will remain bunchy and low for weeks, and then will turn yellow and die as the dry season comes on. On other plats there will be a seed stem thrown out here and there, and a few heads will ripen.

Such is my recollection of the appearance of past crops. We do not intend to sow wheat and barley this year on our fly-infested ground, but the pest may follow our sowing on another part of the grounds, and if it will be of interest to you, I will watch the plants and send you specimens.

Yours very truly,

E. J. WICKSON.

Prof. F. M. WEBSTER.

If the soil is rich and the plants are attacked before they have tilled, these last will be thrown out from the roots which are not injured. These, if the fall be very favorable, and the winter does not commence too early, will often winter through and produce stem-bearing heads the following harvest. On the other hand, if the autumn be dry, or the ground be frozen early in the season, the crop will probably prove a failure. This is the reason why some fields will present a much better appearance the following June, and give a much better yield than could have been anticipated from appearances during the fall. The practical value of knowing how to detect the infested plants readily is in that the destruction may be observed and the damage estimated long before the foliage turns brown or yellow, and the fields be plowed up and resown or allowed to remain, as the owner judges best. If resown, it would seem best to replot also. Mr. W. A. Oliphant, of Pike County, southern Indiana, writing me in the fall of 1884, in reply to circular No. 1, stated that of 300 acres he had resown 200 acres after reploting, and 100 acres without plowing. The first yielded him 27½ and the last 11 bushels per acre.

The popular notion in regard to the effect of larvæ on the straw is, so far as I know, usually correct. This year, however, has been an exception, at least so far as southern and central Indiana is concerned. As far north at least as La Fayette the larvæ of the spring brood were located just above the roots, and the straw did not break at the lower joints, as is usually the case, but either fell or was blown over from the roots, the culm usually being uninjured elsewhere. I observed this to a very limited extent at Oxford, Indiana, in 1881. In fields about La Porte, in the northern part of the State, none of this lower attack of the plant was noticed, the larvæ and later the puparia being invariably found just above some of the lower joints. Mr. James Fletcher, Dominion entomologist of Canada, reported at the meeting of the Entomological Club of the American Association for the Advancement of Science at Indianapolis that the wheat about Ottawa, Canada, had this year suffered from the attacks of larvæ of the spring brood in precisely the same manner as I had observed at La Fayette and southward. Quite a percentage of the pupæ in the fields about La Porte were located so high up the stem as to render it probable that they would be carried away with the straw. As yet I have not found a good reason for this difference, but have a vague idea that the killing down of the plants during the preceding March might have had something to do with it, as this was less severe in the northern part of the State.

THE EFFECT OF THE WEATHER ON THE DEVELOPMENT OF THE FALL BROOD.

It is quite probable that some autumns are more favorable for the development of the insect than others, but just what the favorable influences are is not well understood. Mr. Ratliff, at Richmond, saw an adult emerge from the pupa on October 16; the wheat which it infested appeared above ground on September 4. Between these

two dates, Mr. Ratliff's notes give the following record of minimum temperatures through which the insect must have necessarily passed.

September 23 (frost)	26°
October 6 (light frost)	26°
October 11 (light frost)	34°
October 12 (light frost)	26°
October 14 (heavy frost)	24°
October 15 (frost)	26°
October 16 (light frost)	29°

Rains on September 11, 26, October 19. Total precipitation during September and October, 2.50 inches.

At La Fayette, the same year, I found adults ovipositing on November 3, but of the origin of these flies of course nothing was known. The temperature through which these must have passed, supposing the eggs from which they evolved were deposited after September 1, was as follows:

	Min. temp.
September 23	39°
September 24 (first frost)	29°
October 11	39°
October 12 (frost)	29°
October 14 (frost)	33°
October 15 (frost)	31°
October 16	38°
October 19 (frost)	31°
October 20 (light snow)	37°
October 21	29°
October 22	21°
October 25 (frost)	19°
October 26 (frost)	21°
October 27 (frost)	21°
October 28 (frost)	28°
October 29	33°
October 30 (frost)	19°
October 31	28°
November 1 (frost)	28°
November 2 (frost)	36°
November 3 (frost)	32°

Rains on September 7, 13, 14, 22, 27, 28, 29, 30, October 3, 9, 10, 12, 23. Total rainfall, 4.64 inches.

From this it will be observed that the adult flies may emerge and oviposit under what we suppose to be very adverse circumstances. To what extent the eggs and young larvæ are able to withstand such weather I have no facilities at present for demonstrating. The major portion of the small brood of flies, however, emerge during a more favorable period, and for meteorological aid against these we can only look to the dry, hot weather of July and August, though to the south a portion of September might be included. But the straggling individuals, which, as I have proved, may originate from stubble, volunteer, or even early sown grain, and which I myself can find no satisfactory reason for not considering either the retarded or accelerated individuals of either one or the other or both broods, have it in their power to reproduce a considerable progeny, which, though of themselves not a serious

menace to the crop, yet, added to that of the remainder of the brood, greatly increase the probabilities of serious damage. For these a long, mild autumn, extending into December, would appear to be exceedingly favorable, as it would enable their progeny to enter winter in a comparatively hardy state, and probably produce late appearing larvæ the following year simultaneously with or but little in advance of the progeny of the earlier appearing adults of spring. In other words, the one winters as advanced puparia or unemerged adults, the other as advanced larvæ or newly formed puparia. It thus appears that while the autumn usually has little effect on the major portion of the fall brood, a mild October and November may emphasize the destructiveness of the pest. So far as observed by me, a damp spring, even though a cold one, is also favorable to the development of the insect, while dry, hot summers are as unfavorable, and cause serious mortality to the earlier stages of the fall brood of adults.

PREVENTIVE MEASURES.

These may be noticed as follows: Sowing at the proper time; burning the stubble; rotation of crops; sowing long, narrow plats in late summer as baits; applying quick-acting fertilizers to seriously infested fields in the fall in order to encourage attacked plants to throw up fresh tillers, and to increase the vigor of these that they may make sufficient growth to withstand the winter.

None of the measures are original with me, and in fact the most of them are as old as the history of the species itself. There is certainly much to be gained by the farmer in timing his sowing so as to avoid the larger part of the fall injury, and if all farmers of a neighborhood would sow about the same time even a serious outbreak would be so diffused as to lessen its injury.

The burning of the stubble after harvest, when it is practical to do so, is usually recommended by the majority of writers. The plan is criticised by some authors on the plea that the parasites are also destroyed, which, if allowed to continue, would themselves overcome the fly. This idea has always appeared to me to be both theoretically and practically wrong. If only the normal number of wheat plants allowed by nature to spring up under a perfectly natural environment were produced, then the theory would be correct, because nature would then be working out her plans from the beginning. As the facts exist hundreds of thousands of plants are produced where nature intended but one. Her domain is invaded and her law defied at the beginning. The Hessian Fly is itself a parasite, the wheat plant being its host, and what we term its parasites are practically only secondaries. In the Hessian Fly nature has an efficient servant in controlling the wheat plant, and the parasites of the former seem to be on guard to see that the duty is not overdone. Now we outrage nature and expect that she will uphold us by destroying these servants and permitting the indignity to go on.

With this state of affairs the American farmer has found that the Hessian Fly will be overcome by its parasites only temporarily, and then at the expense of a larger per cent of at least one crop. By burning the stubble we destroy all of the pest and also numerous other enemies which are to be found in the fields at the time. The present season, however, many of the flaxseeds were so situated that it is doubtful if enough heat would have reached them to have destroyed them.

In a rotation of crop the adults are obliged to travel about in search of the fields, and there is a greater chance of their being destroyed while thus engaged. This, however, has its exceptions, as we observed at New Castle, about 30 miles northwest of Richmond, Indiana, on November 17, 1888. The whole field had been sown in standing corn, a portion of it about the 5th of September and the remainder considerably later. The early sown portion had been seriously attacked and at least 85 per cent destroyed; the later sown portion was only slightly injured, as was late sown wheat generally in the community. Here at the Indiana Experiment Station the plan of rotation is as follows: Corn one year, followed by oats one year, wheat one year, clover and grass two years. The wheat fields are never seriously affected by the ravages of the Hessian Fly.

Sowing narrow strips about the fields, early in the fall, as decoys, was long ago strongly advocated by Dr. Fitch, but the advice has been, so far as I have observed, totally ignored by the farmer. While it is hardly possible to thus entrap the major part of the fall brood of larvæ, it is certainly possible to entice to these plats the stragglers and interlopers, which we have shown to be capable of considerable injury. In this way the farmer can, in a measure, continue the influences of summer and winter in sharply separating and defining the two broods. In other words, while he can not eradicate the pest in this way, he can weaken its power to commit serious injury. It is very doubtful if the volunteer wheat, springing up after the wheat has been plowed, can be used as decoys, and if allowed to stand until the date of sowing the fields, these volunteer plants should, by all means, be plowed under as deeply as practicable, or grazed off by pasturing. Simply killing the plants will not do, as has been illustrated by the experience of Mr. Oliphant, previously cited, and by the observations of Professor Forbes in Illinois.* If volunteer wheat is allowed to stand at all, it should not be for over a fortnight. The proper time for sowing these decoys will probably vary with the latitude. For northern Indiana they should be sown during the latter part of August, and in the southern part of the State not later than the first week in September. To the north and south of this I have, as previously stated, no definite information as to the date of appearance of the fall brood of flies, and hence can not undertake to settle the date of sowing. These decoys should not be permitted to stand over four weeks at the farthest, and should be *plowed*

* Bulletin 3, State Ent., Ill., p. 48, 1887.

very soon after the crop is sown, turning the infested plants under and thoroughly covering them. Simple cultivation, whereby the plants are only killed, would probably only destroy a portion of the insects, the full-grown larvæ very likely going through the remainder of their transformations.

The application of fertilizers is, I believe, here in this State confined to the poorer soils, and there more for its general effect on the crops than as against the effects of insects. The idea in late sowing is to retard the plants so that they do not appear until after the greater part of the fall brood of flies have appeared and died, then to overcome the effect of this delay by aiding the plants to make the greatest possible growth before winter closes in, which will the better enable them to withstand its rigors. In this direction, it would seem that the application of proper commercial fertilizers would pay by the effect upon the growing plants, even though the land itself was not in actual want of such treatment. The application to a field which has previously been seriously damaged, with a view of encouraging the throwing out of fresh tillers, is for practically the same purpose; and if there is a tendency to throw out the later shoots freely, if not too late in the season, many may be enabled to secure sufficient vigor to sustain them until spring. Whether it would be more profitable to plow and resow than to try to secure a crop from the infested field by the aid of fertilizers is, of course, a question which each farmer must decide for himself in accordance with the time of year and extent of injury already done.

These measures are all of them practical and entail little if any unusual expense. In fact, good farming presupposes that the most of them will be carried out as among the essential elements of the business. Where clover is to follow wheat it of course precludes the burning of stubble or the destruction of volunteer plants, but it necessitates the rotation of crop, and decoys can be sown and the seeding delayed. It is hardly possible for a farmer to become so situated that he can not carry out some of these measures, and if this were done generally, and every year, the Hessian fly would, in all probability, become of so little importance that it would cease to enter seriously into the problem of successful wheat growing.

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U.S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 24.

THE
BOLL WORM OF COTTON.

A
REPORT OF PROGRESS
IN A
SUPPLEMENTARY INVESTIGATION OF THIS INSECT.

MADE UNDER THE DIRECTION OF THE ENTOMOLOGIST

BY

F. W. MALLY.

(PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.

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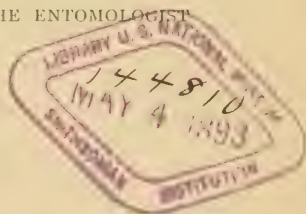
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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., February 27, 1891.

SIR: I have the honor to submit for publication Bulletin No. 24 of this Division. It consists of a preliminary report upon the special investigation of the Cotton Boll worm (*Heliothis armigera* Hübn.) which was authorized by Congress in the bill making appropriations for the use of the Department for the fiscal year 1890-'91.

Respectfully,

C. V. RILEY.
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The present bulletin consists of a report made by Mr. F. W. Mally upon the progress of the special investigation of the Cotton Boll-worm which has been carried on under the Division since the appropriation became available, July 1, 1890. Mr. Mally has had charge of the minor details of the investigation, and has been constantly in the field since last July. He also summarizes the results obtained by Messrs. McNeill and Booth. The Boll Worm was treated at some length in the Fourth Report of the U. S. Entomological Commission, and the chief object of the present investigation was to conduct further experiments with remedies, as well as to verify the value of those already employed. A thorough series of experiments has been planned with the diseases of *Heliothis* and allied insects, in the hope of being able to practically utilize them. Incidentally I have desired to ascertain new facts, if possible, and to verify or disprove what has been previously written in connection with the life history and habits of the species.

The observers have all been hampered in their work by the unexpected lack of material. The funds were not available until the season was three-fourths spent. The observations so far made will, therefore, have to be supplemented the coming spring and summer. It transpires that the ravages of the Boll Worm have been overestimated, and that while from 20 to 30 per cent of the bolls are damaged in an average season in Mississippi, only about one-third of this damage is done by this insect. Several other species which do work somewhat similar to that of the Boll Worm are treated in this report. Some new food-plants have been found, and a careful study has been made of the habits and life history which are here treated with more care and detail than has heretofore been given to the subject. Two new parasites have been discovered, and observations have been made which show that the egg parasite (*Trichogramma pretiosa* Riley) is an extremely important factor in the economy of this insect, as it is, also, in that of the Cotton Worm (*Aletia xyliana* Say), and the Grass Worm or Fall Army Worm (*Laphygma frugiperda* Smith & Abbott). A careful count shows that 84 per cent. of the eggs were destroyed by this useful parasite. All of the old remedies have been once more tested, and the use of corn as a trap crop is again shown to be one of the most satisfactory means of protecting the cotton crop. The old subjects of attracting the moths to lights and poisoned sweets have once more been carefully considered, and my former conclusions have been confirmed, that there is little to be hoped for from either of these methods. The pyrethrum experiments, from which I had much

hope, have not proved very favorable, while experiments with a large series of other vegetable insecticides have given no practical results as yet.

The experiments with contagious diseases can not be reported upon in any detail at the present time; but a large number of cultures of several diseases of the Imported Cabbage Worm, the Bronzy Cutworm and of two other Noctuids have been secured and carried through the winter. What may prove to be a specific disease of the Boll Worm has also been discovered, and cultures have been obtained. It results from the few experiments made that the Boll Worm is probably susceptible to the Cabbage Worm disease, but positive statements can not be made until these experiments are confirmed by those of another season. A bacteriological laboratory has been established at Shreveport, Louisiana, and has been well fitted out with the necessary apparatus, so that work in this direction the coming season will not be hampered, except in the case of an unexpected paucity of Boll Worms.

C. V. R.

LETTER OF TRANSMITTAL.

SHREVEPORT, LOUISIANA, *February 19, 1891.*

SIR: In compliance with your request I have made out a report of progress of an investigation of the History and Habits of the Boll Worm (*Heliothis armigera* Hübner), carried on under your instructions since July, 1890, and submit the same herewith. The treatment of the various subjects is not at all in detail and has only been made complete enough to give an adequate conception of what has been done, the present status of the investigation, and what remains to be accomplished in the future.

Very respectfully yours,

F. W. MALLY,
Assistant Entomologist.

Dr. C. V. RILEY,
United States Entomologist.

THE BOLL WORM OF COTTON.

DESTRUCTIVENESS.

The damage to corn by the Boll Worm is difficult to estimate, owing to the nature of the attack. Its ravages in the "bud" of the young plants and later in the ends of the ears taken collectively no doubt are considerable, though no definite per cent can be given. Tomatoes, cucumbers, and melons also suffer more or less seriously from its ravages. It is the attack upon cotton which is considered most serious and supposed to be of great proportions. To determine the amount of damage to cotton in the regions visited the past season the following studies were made. The first was made August 14, in a large field of upland cotton surrounded by woods. Two rows were taken at random in the field; the first was rank high cotton, the second a smaller growth. About 10 feet of each row were marked off and all the bolls on the plants in each counted. (See Table I.)

TABLE I.

Row.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total.
1.....	290	2	95	389
2.....	270	1	43	314

The next study was made September 16, in a small field of rank bottom-land cotton. The first five plants were taken at random, the next fifteen successively in one row. (See Table II.)

TABLE II.

Plant.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total.
1.....	40	7	5	52
2.....	21	2	13	36
3.....	4	2	0	6
4.....	30	3	20	53
5.....	34	10	34	78
6.....	19	11	20	50
7.....	18	2	0	20
8.....	25	9	15	59
9.....	17	9	12	38
10.....	70	6	9	85
11.....	33	7	1	41
12.....	42	4	9	55
13.....	49	0	4	53
14.....	3	0	0	3
15.....	10	0	0	10
16.....	33	2	2	37
17.....	25	2	11	38
18.....	72	2	24	98
19.....	17	0	3	20
20.....	7	0	0	7
Total ...	570	78	182	830

September 17, a similar study of twenty-one successive plants was made in another portion of the same field. (See Table III).

TABLE III.

Plants.	Worms.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total.
1.....	1	33	4	13	50
2.....	1	23	1	1	25
3.....	2	60	3	2	65
4.....	0	30	3	1	34
5.....	2	41	3	8	52
6.....	0	65	3	0	68
7.....	1	11	1	4	16
8.....	0	29	1	1	31
9.....	0	53	3	1	57
10.....	2	53	5	1	59
11.....	1	24	5	14	43
12.....	0	63	6	25	94
13.....	0	24	0	5	29
14.....	0	19	8	3	30
15.....	0	23	9	12	44
16.....	3	88	13	30	131
17.....	0	22	4	5	31
18.....	0	36	0	2	38
19.....	0	14	0	0	14
20.....	0	20	0	11	31
21.....	0	49	6	39	94
Total.	13	780	78	178	1,036

Table I should not be included in the table of percentages, since its data were obtained early in the season, before the Boll Worm had really become well established in cotton. Omitting table I we have the following table :

TABLE IV.

Percentages from Tables II and III.

Table.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total loss.
II.....	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
III.....	.690	.092	.218	.310
	.753	.075	.172	.247
Average.	.7215	.0835	.195	.2785

The four preceding studies were made by a count of what was actually found on the plants at the time of observation. September 18 only bolls and forms which had fallen were collected and examined. The result is given below :

Number bored by Boll Worm.....	167
Number shed from other causes.....	362
Total	529

Taking the average of the total loss found in the same field on the two preceding days, and tabulated as Tables II and III, and again in Table IV, these 529 bolls may be considered as equivalent to the count-

ing of 1,900 bolls by the method of Tables II and III. This study may therefore be given as below:

TABLE V.

	Number.	Per cent.
Good bolls.....	1,371	.722
Loss by Boll Worm.....	167	.088
Loss by other causes.....	362	.190
	1,900	1.000

Averaging this result with that of Table IV we have the table given below as the result:

TABLE VI.

Data.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total loss.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Table V.....	.7215	.0835	.195	.2785
Study V.....	.722	.088	.190	.2780
Average...	.72175	.08575	.1925	.27825

The above calculations certainly give the Boll Worm as much credit as it deserves, and for the following reasons: The observations were made after the cotton had been "laid by" late in July, therefore the fallen bolls collected from the ground in September covered what had fallen during August and September. This is the period of greatest damage to the cotton. No cornfields near by to lessen and detract from the egg deposition on cotton. This in addition to the consideration of the injured fruit actually on the plants but which was likely to shed, certainly does not make the results arrived at much below the entire damage done during that period.

From the results given above and from subsequent observation it is evident that bottom-land cotton is worse infested than the "hill-country" cotton. Further, even in the same field, as is shown by the record of plants 5 and 10 of Table II and plants 12, 16, and 21 of Table III large, rank, leafy cotton plants, bearing a great number of forms and bolls, are subject to much more serious attack.

The number of forms and bolls which one worm may destroy during its period of existence can only be approximated. From the rate of feeding during favorable conditions and when the larval state is about 15 days the number eaten into may range from ten to twenty. During the longer periods of larval existence caused by unfavorable conditions, the worms are inclined to move about more and perhaps injure more individual fruits, though the absolute amount eaten is not much greater.

What the extent of injury due to Boll Worm over the entire State of Mississippi was the past year will be seen from the closing weather and crop report of Prof. R. B. Fulton, observer, U. S. Signal Service,

University, Mississippi, from which is quoted the following: "In the southern part of the State reports show that on account of injury by Boll Worms and shedding, due to wet weather, the cotton crop will be short from 30 to 40 per cent. of last year's yield. * * * In the northern section the Boll Worm did no material damage." It may further be added that upon application to Mr. George E. Hunt, chief signal officer U. S. Signal Service, New Orleans, Louisiana, for weather crop bulletins and the names of observers who had reported much damage to cotton by Boll Worm last season, he replied that no material

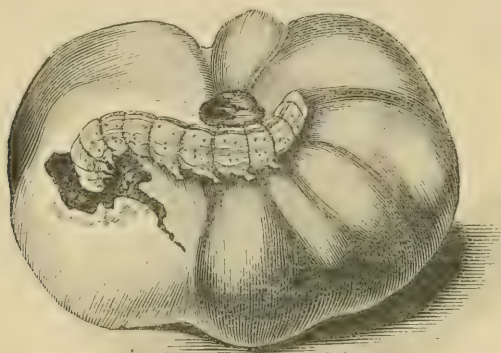


Fig. 1. *Heliothis armigera*; full-grown larva eating into a tomato—nat. size (after Riley).

damage was done from that source and none had been reported by any of the volunteer or other observers. From this information as also the facts shown by the preceding tables it is quite evident that the depredations upon cotton by Boll Worms have been greatly overestimated. If the statements of planters living in the regions where observations were made are accepted, the Boll Worm was fully as numerous if not more so than in previous years. Nearly all agreed that the damage was fully up to the average, others thought it above the normal, but none estimated it as being lower than usual. These statements together with the almost daily reports obtained from interviews that "one-fourth or one-third of the crop was being ruined" (?) led to above careful studies. The results simply show that on the whole the planters fail to distinguish the Boll Worm ravages from those of other insects, from physiological phenomena of the cotton plant, and lastly, from some of the fungoid diseases. In order to assist the planters in this matter a few observations have been added at the close on "Other insect ravages easily confused with those of the Boll Worm."

FOOD PLANTS OTHER THAN COTTON.

Corn.—The habits of the Boll Worm when feeding on corn have been so fully presented in the Fourth Report U. S. Entomological Commission, pp. 359-361, that only such observations will be given as verify

important points or add to our knowledge of the species. The manner of attacking the ears of corn and the semi-solid excrement of the worm which is left behind along its path into the ear, paves the way and provides a fertile soil for the germination and subsequent growth of all kinds of molds. The additional decay resulting in this way, aided by the ravages of Dipterous and other larvæ which revel in such matter, perhaps fully equals the actual damage done directly by the worm. In large fields of corn not often more than one large worm is found in a single ear, but when the fields are small, and especially when surrounded by cotton fields, there are often three or four nearly grown worms in a single ear, and perhaps as many more newly hatched ones. This is a direct result of the preference of the moth for the corn when the latter is in close proximity to cotton fields and of suitable age. When the field is small the female often passes through it several times during a single flight, depositing eggs as she does so. In this way I have often observed the same female deposit eggs three times on the silks of an ear of corn during a single visit. This of course is not the normal method of deposition, and occurs only under the circumstances mentioned. If it were so the numbers of worms would be greatly reduced through the agency of their cannibalistic habits, to be discussed hereafter in considering the history of the worms. Other females visiting the field may also deposit on the same ears of corn, and so on. As a result of this as high as fifteen to twenty-five eggs have been found on the silk of a single ear of corn, and in addition as many more on the husks and leaves.

In regions where corn is cultivated extensively a second crop is planted late in July to produce a fodder crop by the end of the season. These fields are invariably badly infested. When these are near cotton fields they afford a great protection to that crop.

Except on cotton, hereafter considered, no observations of special interest were made on any of the other well-known food plants, though it was noted that the tomato crop suffered severely from Boll Worm depredations.

Other Plants.—As additional food plants of economic importance which are attacked by Boll Worm are to be mentioned the muskmelon, watermelon, and cucumber. The cucumber is attacked usually by eating a hole near the base from below up into the center and then tunneling the length of it to the anterior end. The melons are usually bored from the under side near the base, but occasionally at almost any other point. The female was seen depositing on the following weeds: *Helenium tenuifolium*, *Amarantus retrofractus*, *A. spinosus*, probably *Erigeron canadense*, and one undetermined species of *Panicum*.

It was evident, however, that the young worms did not relish any of the above weeds as food plants and left soon after hatching. This was further verified by taking some branches of the plants just named to the laboratory and placing newly hatched worms upon them. They

fed sparingly upon the small flowers and tender stems, but soon left the branches and could not be induced to remain long. The female shows no inclination whatever to deposit her eggs upon the last-named host-plants except as they may be found in corn fields or near by. From here the young worms can easily migrate to the corn plants near at hand, and from observations already cited it is quite probable that they do so. These last observations have, furthermore, led me to suspect that the female may occasionally deposit upon all weeds or other plants indiscriminately growing in a corn field and suitable for this purpose.

CHARACTERS AND TRANSFORMATIONS.

THE EGG.

The egg is oval, the greatest diameter being very near the base. It tapers but little from the point of greatest diameter to the base, but slants much more towards the apex. The vertical diameter averages 0.375 millimetres, the horizontal and greatest diameter 0.5 millimetres. The sculpture of the eggs consists of polar ribs with cross bars, giving them a checkered-appearing surface. When first deposited the egg appears nearly a pure white, but soon turns yellowish as the growth of the embryo begins, and deepens as the latter develops. After about 25 or 30 hours that part of the embryo at the apex of the egg is noticeably darker, and between it and the center of the egg a reddish or brownish band is formed. The latter so far as can be seen extends only part way round the egg.

This band is later absorbed into the body of the worm and the darker spot at the apex is found to be the head of the developing larva. At this stage the body of the worm can be quite definitely seen through the eggshell.

The duration of the egg state varies somewhat, as will be seen hereafter, with the meteorological conditions prevailing at and immediately following the time of deposition. One lot of eggs deposited in confinement at night and followed by two very hot days began hatching within 45 hours. But of a number of lots of eggs deposited in confinement from time to time, the duration of the egg state was usually from $2\frac{1}{2}$ to 3 or $3\frac{1}{2}$ days. This may be considered about the normal duration of the egg state. Several lots, however, which had been deposited during unfavorable weather did not hatch until after 4 days; in a few instances a few hours over 5 days.

THE LARVA.

The newly hatched larvæ, before they have taken any food, average 1.54 millimetres in length, are slightly larger anteriorly, tapering gradually, as is shown by measurements of the diameters of a number of worms at the first, middle, and last segments, whose averages were 0.23, 0.20, and

0.14 millimetres, respectively. The general color of the body is white, with a yellowish tinge; head, black; a black or brownish shield-shaped spot on the dorsal surface of the first segment.

Soon after they begin feeding the larvæ turn darker and before the first molt are usually of a deep rose or brownish color. The piliferous tubercles are not yet very prominent. The true legs at first are slightly

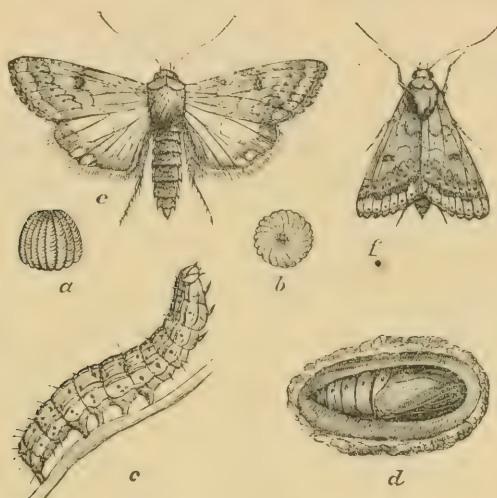


FIG. 2.—*Heliothis armigera*: a, egg from side; b, do. from top—enlarged; c, full-grown larva; d, earthen cell with contained pupa; e, moth with wings spread; f, do. at rest—natural size (after Riley).

dusky, but soon turn much darker, are hairy and provided with a small bifid claw. At first the first pair of prolegs seem to be a little less robust than the others, and hence may be slightly weaker. Obscure dark lateral patches are found on the prolegs, which at this stage are further provided with fine small hooks.

By the time of the first molt the worm has attained a length of 5.62 millimetres and is slightly larger in the middle.

After the first molt the larva is at first of a yellowish color, but again turns darker rapidly when it begins feeding. The true prolegs become much darker, and at their insertion next the body a small dusky spot, both anteriorly and posteriorly, is found. The dark lateral patches on the prolegs are also more distinct, each proleg being now provided with nine small hooks.

By the time of the second molt the larva measures 7.75 millimetres in length and is still a little wider in the middle.

Soon after the second molt the worm measures 8.75 millimetres in length. The most noticeable changes are, that the piliferous tubercles are now much more prominent; that the very small tubercles found thickly scattered all over the body first become quite discernable to the naked eye.

With the three subsequent molts there are no marked changes except in size and the distinctness in definition of the various colorings and markings of the body of the larva.

The mature worm varies in length from 31 to 36 millimetres, with diameters of about 4, 5, and 4 millimetres at anterior, middle, and posterior regions, respectively. The head of the mature Boll Worm is never darker than a light brown, or, in the darker colored worms, mahogany, but may be paler according as the specimen is a lighter colored one. The true legs are dusky or blackish, as also the spots on the prolegs. The latter are now each provided with fifteen small hooks.

The color of the body of the mature worms varies from all gradations of the darker or rose-colored specimens to those which are light-greenish with a faint rose tint or entirely light-greenish. The darker colored ones greatly predominate from about August on through the remainder of the season. The markings of the worms which are most frequently met with at this time are as follows:

Along the median line of the dorsal region is a brownish or blackish stripe containing in its center an interrupted white line. Next, the subdorsal stripe, which is lighter colored, and along which is found the first subdorsal row of piliferous tubercles. Below this is a subdorso-lateral stripe, which is usually about the same color as the dorsal one. The subdorso-lateral stripe is slightly wider at the center of each segment, and within its borders are found two more rows of piliferous tubercles. Next comes the lateral or stigmata stripe, which is usually pure white. Along this stripe are found the spiracles and one row of piliferous tubercles. Between the lateral stripe and the prolegs is a stripe, which is usually of the same color as the ventral surface, which latter is a uniform whitish. This sublateral stripe contains two rows of smaller tubercles. In many of the darker rose tinted specimens this stripe is often nearly a pure rose color, in which case the stigmatal stripe is also more or less tinted. Throughout all the stripes except the lateral and sublateral ones, and in these where they are colored other than white, are found numerous interrupted, irregular, white lines and spots. The stripes are all of a uniform width throughout, with the single exception mentioned. In the lighter colored specimens none but the dorsal and subdorso-lateral stripes can be distinguished at all, and often only the dorsal one.

The first segment is provided dorsally with a denser, calloused part irregularly shield-shaped and which is pale brown or black, according as that is the general color of the worm. In the newly hatched worm, however, it nearly always appears as a very distinct black patch. This calloused portion has a distinct median groove dividing it into two symmetrical halves, each of which bear similar markings as follows:

Four small pits in the form of a trapezoid, the posterior pair being nearest together; from each of these pits extends a fine short hair. In the center and extending each side of the median line are two deep

transverse parallel grooves. At the curved lateral regions of the shield are found slight depressions, and again one at the posterior end of the median line. The shield is further traversed by irregular lines or wrinkles, and in addition contains short white interrupted lines and spots much the same as those found in the stripes of the body. Dorsally the second and third segments each have a transverse row of four piliferous tubercles. The fourth to tenth segments, inclusive, have each four piliferous tubercles, slightly larger than those of the second and third, and are arranged in the form of a trapezoid, the anterior pair being nearest together. On the eleventh segment the four tubercles are arranged in the form of a square; on the twelfth the trapezoid is reversed, the posterior pair of tubercles being nearest together.

Laterally, the first segment is provided with a spiracle about which are two piliferous tubercles. Below there are two smaller tubercles which are usually contiguous and appear much like one tubercle from which two bristles project. The second and third segments each have two large piliferous tubercles, two slightly smaller ones and two still smaller. The fourth to eleventh segments inclusive each bear three tubercles arranged in triangular form about the spiracles with a fourth smaller one below them. The twelfth segment usually has two placed contiguously, or nearly so. Ventrally the tubercles are all small. The fourth segment bears six small tubercles arranged so as to form the arc of a circle. The fifth segment has two transverse rows of tubercles, four in each, the ones in the anterior row being wider apart than those in the posterior. The tenth, eleventh, and twelfth segments each bear a transverse row of four tubercles. All the tubercles throughout have projecting from them a short, stout hair, or bristle.

The growth of the larvæ is somewhat slower during their earlier stages than when half grown and approaching maturity.

When nearing maturity the molts occur at shorter intervals. The intervals between molts become longer later in the season or with cold and unfavorable weather. Thus in August the first molt occurred on the fifth day after hatching, the second on the tenth, the third on the fourteenth, and the fourth on pupation, seven days later. September 25 some eggs began hatching; the first molts occurred on the seventh and eighth days thereafter, the second on the fifteenth and sixteenth days; at this time the particular worms under observation made their escape and the interval of subsequent molts could not be recorded.

The length of the larval state is longer later in the season. Thus at Shreveport, Louisiana, Dr. A. R. Booth reports that during August a worm matured and was preparing to pupate after having fed 15 days; another after 18 days. At Holly Springs, Mississippi, for the same month worms matured within 18 to 20 days after hatching. For September worms hatched about the first of the month, matured in from 21 to 26 days, while larvæ hatched September 25 escaped after 18 days and had only just molted the second time.

The first food of the worm is the eggshell from which it has just issued. No sooner is the young larva fully out of its shell than it crawls away once or twice its length, turns around, and eats the shell either entirely or but a portion of it. This done it crawls about a short time until it finds a spot suited to its taste, usually first spreading a few threads of a frail web. Under this the worm feeds on the epidermis of whatever surface it may have selected. Often they crawl but a short distance, drop themselves down by a slender thread until another surface is struck, when they crawl away as before and begin feeding.

Before the first molt the larvae feed principally outside of the young forms and squares on whatever surface they may be when hatched. At about the time of the first molts, or soon thereafter, they begin seeking out the forms, blossoms, and squares and begin their destructive work of boring into them. It must be stated, however, that from the first a few may be found to go directly to a small form or square and either boring through the involucre and thence into the blossom or fruit, or else first crawling between the involucre and fruit and then boring into the latter. Often, too, they at first simply hide behind the involucre, eating the epidermis from the inside and boring into the fruit later. Preferring the tender growing portions of the branches, the younger worms after finding them secrete themselves in the opening clusters of leaf and flower buds and begin boring.

Their first feedings upon the leaves, whether on the upper or lower surface, are principally confined to the epidermis. About the time of the first molt they begin to eat small holes through the leaves. This is not continued long, however, as at this time the worms begin their search for the forms and squares. During the younger period the worms feed most on the reproductive organs of young forms or such as are nearly grown and opening. Some time later, after about the second molt, they begin boring more plentifully into the larger bolls. The older worms, while feeding principally in larger bolls, do not confine themselves to them and are often found devouring a form or opening blossoms. Due to their choice of food (speaking only of the bulk) the younger worms are found mostly on the younger tender-growing portions of the cotton plant, and the more nearly grown ones on the more mature portions. For a change the full-grown worm sometimes feeds on a leaf or eats through the green stem of a newly formed branch. Stems which were .25-.30 inch in diameter and having above them a number of forms have been observed to be eaten nearly through by them. A day or two after the branch would be found wilted or nearly broken off.

The habits of the worm, as to the manner in which a boll is entered and the extent to which it feeds upon the same after it has entered, are also rather variable. The worm may pass in behind the involucre and bore into the boll from the inside, or it may choose to do so from the outside, eating through the involucre and then into the boll. The hole is usually bored from the bottom and passes towards the apex; fre-

quently, however, the hole is bored about midway of the boll and passes straight in. As the worm thus feeds on the inside of the boll it may pass straight towards the apex, devouring only the section of the fruit which it has entered and then retreat, and attack another boll, or it may bore through the partition into a second section, devouring it, or the passage of the worm may be a slanting one from the first, in which case two or three sections may be entered before retreating. The worm seldom continues until it has destroyed all of the sections of the boll, though the remaining sections are usually made worthless by the decay which arises and spreads from the injured portions.

The notion which some planters have that the worm eats in at one point on the boll and passes out at another is wrong, for if it ever does so it is certainly the exception. Occasionally, however, there are two holes in a boll similar to those which the Boll Worm makes and indeed the Boll Worm has been the culprit. Observation, however, has proven that the Boll Worm occasionally begins boring at one point, eats into it but a short distance, retreats, and begins a second hole at another point on the same boll. Sometimes, also, two worms are found attacking the same boll, which, when they have finished and left it, appears as if a worm had entered at one point and passed out at another.

It is further believed by some that the Boll Worm travels *only* at night and feeds only late in the afternoon and evening. Concerning both it must be said that the worms avoid the extremely hot sunshiny part of the day, and prefer traveling and feeding during the cooler parts; but at the same time considerable range must be allowed for the whims of the worm, and other conditions which may arise to induce the worm to go from boll to boll during mid-day and often at high temperatures. As bearing on this it may be stated that often while making morning observations in the cotton fields worms were found in bolls. Without any disturbance these branches were marked so that they could be easily found for experimental purposes in the afternoon. In the afternoon it was always found that a number of worms had gone to other bolls or even branches on the same plant. Occasionally, too, one would be found to have left the plant entirely and could not be found. The changing of plants was not often done during the day, but was oftener found to be the case with those specimens which had been marked the preceding evening and were looked for the next day. The changing from boll to boll on the same plant may be frequently observed during the day. The time of day when the worms feed most vigorously is during the cooler portions of the afternoon and evening and in the morning before the sun shines so hotly.

After the killing frosts in late October and November the worms which had not yet matured were found to feed as best they could upon the berries of *Solanum carolinense*, and possibly, if forced to, would feed upon any other available green plant found in the cotton fields. Extensive observations on this point could not be made, since the worms

were not at all plentiful. It remains to be added that the larger Heteropterous insects, mostly *Metapodius*, were abundant upon *Solanum* at this time, and that probably great numbers of the remaining immature worms fell a prey to them.

The cannibalistic habits of the Boll Worm are also of importance and must be considered here. First to be mentioned in this connection is the fact that the Boll Worm devours its larval skin as soon as molted and does so before it begins feeding on vegetable matter again. When collecting worms from the fields considerable care must be exercised to have a box or basket large enough to receive some foliage, in order that the worms may not injure and destroy each other before reaching the laboratory. In the breeding cages the Boll Worms not only attack each other, but almost any other larva placed in the arena. In a state of nature they have not been observed to deliberately attack each other except in corn, especially when the field was a small one, and great numbers of eggs are deposited and hatched on the same plant, so that an unnatural number of worms expect to feed upon the same ear of corn. The same may be said concerning the "bud," if the plant be young yet.

In several instances where such small fields of corn were found near large cotton fields, examination of the ears resulted in finding from three to six worms of various sizes in them. A day or two later when the same ears were examined some of the smaller ones were found to be badly bitten (enough to cause death), and some dead ones whose bodies gave evidence of a violent death. None of the worms had been devoured, and it seems that the warfare had been brought about by the worms intruding on each other's territory, as feeding progressed, and that nothing more was done than would maintain their positions.

THE PUPA.

A number of Boll Worms which had been fed on bolls in breeding cages matured and were placed in a fruit jar about two-thirds full of earth. The worms at once entered the earth, formed their cells, and pupated about 2 or 3 days after. The pupa is a beautiful green at first, but soon turns to a light brown or mahogany. When all the worms had pupated the earth was examined to determine something about the depth of the burrows and cells and the manner in which they were made. The earth had been recently placed in the jar and was quite loose when the worms were placed on it. The depth of the burrows varied from $2\frac{1}{2}$ to 5 inches and throughout their course were partially filled with loose earth. The cells were all much larger than any part of the burrows and extended upward from the end of the same. One worm had come to the surface of the glass in making its burrow, and was observed while making its cell. The worm seemed to test carefully every part of the wall of the cell to see that all was firm. The whole surface was then thinly coated with a sticky fluid, at the same

time adding a small amount of webbing. The latter was plainly to be seen on the glass of the jar.

Some of the mature Boll Worms which had been left in the breeding cage without earth pupated unprotected on the floor of the same and later issued as moths. In another instance, however, the mature worm had been left in a newly-made breeding cage. The next morning the worm was found to have nicely webbed together the sawdust accidentally left in the corner, and had formed a neat little cell, which might almost be called a cocoon. This shows plainly that the Boll Worm is capable at least of spinning a certain amount of web for its cell, whether it always does so to so great an extent or not.

It was stated above that the worms pupated about 2 or 3 days after having entered the earth. This, however, applies only to the months of August, September, and October. Later the time is longer, as is shown by the following observations: On November 1 a mature Boll Worm from a breeding cage was taken to a cotton field and placed on solid earth, a large open tin can being placed about the worm so as to compel it to make its burrow under observation. The work of digging its burrow was begun at once, and by the next day it had disappeared below the surface. A small conical-shaped mound of loose earth was formed about and over the opening of the burrow. On November 4 two other mature Boll Worms were similarly placed in open cans, the one on solid earth, the other on earth which had been dug up and made very loose. So far as could be seen without digging the burrows were made exactly as the one just mentioned.

On November 14 all the burrows were carefully followed up with a small trowel, to determine depth, condition of the burrows and cells. The worm placed on solid earth, November 1, had proceeded as follows: Down for an inch, then slanting at about an angle of 120 degrees for 2 inches more when the cell had been made upward. The cell was about an inch and a half long, and was therefore within an inch or less of the surface. Very little webbing was noticeable along the burrow, and but little in the cell. The burrow was about 0.25 inch in diameter, larger at the distal end, and contained a small amount of loose earth along its entire length; also a plug of loose earth about 0.25 inch long at the distal end next the cell. Having been in the earth 2 weeks, I was surprised to find that the worm had not yet pupated. The burrows and cells of the other two worms were examined, but no special difference worthy of note was found. The peculiar facts in all were: (1) That the cells were all inclined and higher than the lowest part of the burrow, thus bringing the pupa above the latter; (2) that the cells were so near the surface; (3) that the larvæ were all found with their heads at the upper end of the cell, wherefore the pupæ would have been found with the anterior portion highest and resting on posterior end; (4) that they had not pupated after having been in the earth so long a time.

The duration of the pupal state as noted by Dr. Booth for August to September 2, was 10 to 11 days. At Holly Springs, Mississippi, a number of worms pupated between August 28 and 31. Some of the pupæ issued after 15 days and others not until after 27 days. Two others which had pupated September 4 and 7 issued September 20 and 30, making 16 and 22 days for the pupal state, respectively. Another worm pupated August 31. This pupa was alive, but had not issued at last observation, October 20, when it was injured and died later.

For description of pupa see Fourth Report, U. S. Entomological Commission, p. 371.

THE IMAGO.

For description of the moth see Fourth Report, U. S. Entomological Commission, p. 371.

The sexes of the Boll Worm moth can usually be readily recognized, especially if but a short time has elapsed since their issuance. After the females have deposited most of their eggs and their wings have become worn and battered the sex is less easily distinguished. The body of the female is noticeably more robust than the male; especially the abdomen, which is distended somewhat by the eggs which are being matured. The end of the abdomen is ovoid, acute, the tip not provided with so large a tuft of thick hairs as is that of the male. The abdomen of the male tapering more gradually is slightly longer, of less diameter, and more cylindrical.

When feeding or ovipositing, the flight of the moth is much slower than when flying long distances. The moth approaches a flower or gland, often steadying itself with the fore legs, in any case fluttering its wings rapidly, with antennæ in constant motion. Sometimes they alight to sip sweets, or perhaps to rest; in either case the wings are not closed down upon the body, but are partially spread and elevated, leaving bare the abdomen. If, however, the moth alights to hide, the wings are folded down closely upon the body. Much the same flight is observed in the female when ovipositing, sometimes alighting to do so, but usually only steadying herself with the fore legs. In the act of oviposition, the abdomen is bent forward sickle-shaped, bringing the apex squarely upon the surface to be deposited on. The time occupied in depositing an egg in this manner is equivalent to the time it requires to count three or four slowly. At this rate, and in the interval of flying about from plant to plant, some half dozen eggs are deposited, when the moth is seen to fly away. So far as can be determined these intervening flights are for the purpose of feeding and rest from labor.

Though the habits of the Boll Worm moth have been classed as nocturnal, and they are principally so, yet its diurnal habits are perhaps of greater importance than has hitherto been supposed. During continued daily observations on the Boll Worm in the field the moth was frequently seen flying about, and at times observed to feed. Upon closer obser-

vation it was found that on pleasant sunshiny afternoons the moths flew about quite plentifully, feeding freely during their flight. Often while standing in a patch of cowpeas, from about 3 p. m., have I observed the moths, without any previous disturbance, rise here and there, fly about the pea blossoms or the glands at the base of the young pods, sip their exudations for a few minutes at a time, and then fly away a short distance, alight to rest and hide. In the early part of the afternoon the length of their visits to the pea blossoms are short and the time of their hiding longer than later. About 5 to 6 p. m., when the sun is yet quite high, the moths begin to fly for a longer time and their hidings are of shorter duration.

My own experience with the moth has been that it feeds freely from about 4 p. m. until sundown, when the females begin depositing their eggs, feeding being apparently a minor matter at this time. The moths thus seen flying about in the afternoon are not confined to one sex, though the males predominate during the earlier period until an hour or so before sundown, when both sexes appear presumably in about equal numbers. The favorite food of the moths at daytime are the blossoms and other secreting glands of the cowpeas; they also feed freely on clover and *Helenium tenuifolium*. During the day the moth is seldom met with in the cotton fields either as feeding or by being flushed. It therefore appears that during the day the moth prefers to hide and feed upon plants some distance away from the cotton fields. During twilight and night the moths are found abundantly in corn and cotton fields, and feed almost entirely upon the exudations of the various glands found on the cotton plant.

But not only are the feeding habits of the moth partly diurnal but also those of the deposition of eggs. Though on several occasions a moth was seen depositing eggs on corn, and once on cowpeas in mid-afternoon, the habit is not one of frequent occurrence.

These diurnal habits of feeding and occasional deposition are of great importance in the consideration of the utility of lights as traps for catching the moths at night, and will be taken up more fully in that connection.

The number of eggs which a female may be capable of depositing is difficult of absolute determination, but has been shown to be much greater than was supposed. A female which had issued in confinement was placed in a breeding cage with a male which had issued the succeeding day. Five days after deposition of eggs began, and continued for 7 days. During this time 687 eggs were laid. Unfortunately, the female which was thus under observation after having died became mixed with other dead specimens on the table and hence no dissections were made with a view of determining whether any well developed eggs remained in the abdomen or whether the number of potential ova was great. A female captured August 5, and confined in a box deposited 627 eggs in one night. Another, captured August 8, and

kept in the same manner, deposited 468 in one night. Another, captured August 14, deposited 505 eggs the first night, was kept in a tin box without food during the next day and deposited 125 eggs more on the second night, making 630 in all. The first female spoken of above as having deposited her 687 eggs on seven successive nights did so as follows, beginning with the first night and continuing in order: 49, 5, 10, 436, 147, 22, 18; averaging 98 per night.

The life of the moth was probably shortened by confinement, and therefore the average number of eggs deposited each night is entirely too high for oviposition under normal conditions. The record, however, shows that a climax in egg deposition is reached after a certain period. (The possible importance of this fact is considered under the head of lights as traps for the moth.) The total number of eggs deposited by the four females above noted was 2,413, averaging 603 per moth. But the number of eggs deposited in one night by the moths captured and confined show that their period of greatest egg deposition had already been reached by them. Judging from the record of the moth whose deposition of eggs was observed from the first, it seems safe to suppose that probably each of the other moths had deposited about 50 eggs previous to being captured. This would raise the average to 653 eggs per female. But again, from dissections of the females thus observed in confinement it was found that a number of well developed eggs remained, and usually also a great number of potential ova. The average of 653 eggs per female is therefore certainly not too great and probably much too small.

What the number of eggs deposited in one night in a free state of nature are can only be approximated. As has been stated the female deposits four, five, or more eggs in succession, then flies away, feeds or rests a time, afterwards repeating the process. The interval of nondeposition is necessarily variable, though as near as can be determined about 5 to 15 minutes. How long deposition is continued during an evening is also not to be definitely stated, though it is noticeable that the moths begin to decrease greatly in numbers soon after 8 o'clock, thus approximately the time is about 2 hours. From these data it may be approximated that from about 30 to 60 eggs are normally deposited in a single night. For the nights during the period of greatest deposition, the number deposited is probably much larger.

Upon the number and distribution of the eggs upon the various parts of the host plants the following data are collated: By actual count the number of eggs found on five corn plants is as follows, in averages: per plant, 74 distributed as follows: tassel, 10; leaf sheaths, 10; leaves, 14; husks of ears, 15; silks, 25. The above count was made in a small patch of corn surrounded by cotton fields with no other corn near, wherefore the number of eggs per plant was perhaps greater than on plants in larger fields of corn. (This point will be considered more fully under corn as a protection to cotton, which see.) Of five cotton plants

the number and distribution of eggs in averages was as follows: per plant, 7; leaves, 4; involucre, 1; stem and petiole, each, 1. These are the data for plants examined at random at different times while making observations. Bearing upon the choice of the place of deposition the record of the female already spoken of as depositing in confinement is interesting, and for the whole period of deposition was as follows: on leaves, upper side, 37; under side, 110; stem, 23; petiole, 51; involucre, 4;

The eggs are deposited upon quite a number of host plants. Corn is unquestionably preferable if not too near maturity. Cotton perhaps ranks next, though they deposit freely upon cowpeas. In addition to these the moth was observed to deposit on the flower heads of *Helenium tenuifolium*, *Amarantus spinosus*, and *A. retroflexus* with *Datura stramonium*, upon which the moth feeds occasionally, *Erigeron canadense*, and a species of *Panicum*, on the doubtful list. Deposition was not actually observed on any other host plants, though presumably the moth will deposit on those plants upon which the worm is known to feed.

The food of the moth is quite diversified. During the night, so far as observed, the secretions of the various glands of cotton seem to be their main food, while during the day the same may be said of cowpeas, *Helenium tenuifolium*, and to a lesser degree of newly protruding corn tassels; occasionally, *Amarantus retroflexus*, *A. spinosus*, *Datura stramonium*, and perhaps some of the grasses. There may be many other flowers, glands, possibly also fruits, which are visited, but which did not come under observation.

The regular flight of the moth is very swift and never very high. In flying some distance in a cotton field it seldom rises to the level of the tops of the cotton plants, but flies lower, darting this way and that between the plants and foliage in the rows, and in this way from row to row across the field. This manner of flight is also of importance in adjusting lights as traps for them, and is referred to its appropriate heading.

During the greater portion of the day the moths remain hid. If in corn field they are found down behind the sheath of the blades of the stalks, about two or three feet from the ground. But most of the moths hide outside of both corn and cotton fields, around the edges in the weeds, under dried grass and rubbish, or in adjoining fields of clover or cowpeas. When found hiding in these places they are usually upon or near the ground, wings folded upon the body, and so located that a dried blade of grass or other object quite completely hides them from view.

NUMBER OF BROODS AND HIBERNATION.

Observations having only begun in August, the notes taken begin with the fourth brood, which is the one which first begins to deposit freely on cotton.

The broods overlap each other mostly as a result of a difference in the rapidity of growth of many of the worms. One lot of Boll Worms obtained from eggs deposited in a breeding cage by a single female in a single night, and later hatched on the same date, were reared under the same conditions. Some of these worms matured and entered the earth for pupation, while others were yet but half or two-thirds grown. Due to such great irregularity in the length of the larval state fresh females of the fourth brood may be found along with the first to issue of the fifth brood in September. Not much work of the Boll Worm in cotton is noticed until August or early in September. From about the middle of September the moths of the fifth brood begin appearing, and continue to the last of the month, or even the first of October, after which time they are not often met with. At least a partial sixth brood begins appearing late in September and early in October, and consist principally no doubt of those individuals that have undergone their transformations rapidly. That all of the sixth brood does not appear is evident from the fact that they are fewer in number than any of the earlier broods. Hence many of the pupae of the fifth brood of moths pass through the winter as such and form a part of the first brood in spring. The moths of the last brood appearing so irregularly, worms hatched from eggs of this brood are found in all stages as late as November 20 to December 1. At Shreveport, Louisiana, during this period Boll Worms were found on cotton which had only molted the second time and were therefore only about one-third grown.

But this irregularity in duration of certain stages of the insect is not confined to the larvæ, but to the pupæ as well. Of a number of pupæ which had been kept over from September and October one issued at Shreveport, Louisiana, December 12. Whether the moths, if there be many which issue at this time, hibernate as such or deposit their eggs at once and die soon after, has not been determined positively. If the latter be the case, the progeny will certainly be entirely lost, since no living food plants are found at this period. The Boll Worms which were yet immature at the time of the killing frost early in December were quite certainly destroyed, as nothing remained for them to feed upon. As to whether the moths hibernate, I can only say that close and continued search during December has failed to discover the moth. This may not be surprising, however, since certainly the moths which issue at so late a date, and which would therefore be likely to hibernate, are very few in number, and hence would be met with perhaps only accidentally during the winter season. Though a few moths issue at so late a time as has been mentioned, the other extreme is also met with in the pupal state. Evidence of this is the fact that several pupæ which were obtained from breeding cages late in August had not issued up to November, when they were still alive, but were accidentally injured and died.

It must be kept in mind throughout in speaking of certain stages of

the species that a majority only of that stage is referred to. It should further be remembered that these observations apply only to the northern region of "the cotton belt" and doubtless can be much enlarged upon by observations in more southern portions.

NATURAL ENEMIES.

The fact that the Boll Worm was so scarce during the past season precluded making extensive observations along this line.

Among the vertebrates only circumstantial evidence was obtained. In one instance where the dis severed wings and torn bodies of *Heliothis* were found under and near a large tree in a cotton field it was also found that a "butcher bird" had its nest on one of the upper branches. Another was the case of a negro tenant, who complained about the crows lighting on his corn plants in the field and eating into the end of the ears. Upon examination it was found that the corn was badly infested with Boll Worm. This alone could not serve to establish the fact that crows picked into the ears for the primary purpose of feeding on the worms. Feeding on the tender grains of corn beneath the husk quite probably an occasional small Boll Worm was eating. It is also probable that still others will be injured by the pecking into the ends of the ears. The crops and stomachs of a number of quails were examined and though they had them shot about cotton fields no Boll Worms were found in these parts of their digestive organs. Upon visiting the fields about which they had been shot no Boll Worms could be found and the negative result has therefore no great significance.

A common species of Soldier bug (*Podisus spinosus*) was found devouring a large full-grown Boll Worm. An immature capsid (near *Leptoterna*) was overlooked and left on a branch of cotton placed in a breeding cage for a female to deposit upon. Soon after deposition some of the eggs showed signs of shriveling and were supposed to be sterile. Close examination, however, led to the discovery of the destroyer, which was as yet but a pupa. The eggs being nearly empty it was evident that the pupa had punctured the eggs and sucked their contents. The same pupa was then placed on a branch of cotton with some newly-hatched Boll Worms, all of which fell victims to its beak. A common species of the robber flies (*Erax lateralis*) was also seen to catch the moth while on the wing.

No observations could be made upon ants in relation to the Boll Worm, since the latter were not abundant enough for that purpose. The ants have been watched on corn for an hour without noticing an attack upon the eggs found deposited there. They are occasionally seen to enter the holes through the husks into the ears, but I did not observe that they went in for the purpose of attacking the Boll Worms. They only sipped freely of the juices and ferments of the injured kernels of corn and the excrement of the worms. Sometimes dead worms are

found in the ends of ears into which ants have entered, but the condition of the worms plainly indicates that they had not been bitten or tormented to death. In fact, worms under similar conditions, except the absence of the ants, are often found, but from which parasites are usually bred. A nearly grown Boll Worm was placed in the path of a great army of ants, but was not caused any great inconvenience by them. Sometimes an ant would run up on the back of the worm, but the twisting, jerking, and rolling of the worm soon displaced the intruder and the worm escaped uninjured.

Of the three parasites, the one attacking the eggs (*Trichogramma pretiosa*) is most important, though there are at least three others attacking the worms. A small Chalcid* was bred in great numbers from a Boll Worm captured in the field and transferred to a breeding cage to rear. The worm had been dead for a day or two before the parasitic larvæ issued from its body. These did not form silken cocoons but pupated nakedly on the side of the glass bottle. At least two species of *Tachina* deposit their eggs on the backs of the worms. The one deposits a pure white egg, the other a deep brown or black one.†

Both kinds are of the usual form and size of *Tachina* eggs. Great difficulty has been experienced in rearing the dipterous larvæ after issuing from the dead body and I have thus far obtained no adults.

As already stated, the most important parasite is the small *Trichogramma* of the egg. The number of eggs which were found to be destroyed by this parasite was simply amazing. In small patches of corn near cotton fields it was noticed that of the many eggs found on the husks and blades but a few retained their normal color, but soon turned dark or entirely black. Of the 57 eggs taken from some 8 or 10 corn silks from this field October 18 only 7 hatched. The remainder were kept in a vial for a time, when later the parasites issued in abundance. In this instance 84 per cent of the eggs had been destroyed by the parasites. This per cent may be a little too high for the average, but judging from the large majority of eggs seen on the plants, which were black and evidently parasitized, it is certainly conservative to say that during the Fall season 75 per cent of the eggs are destroyed through its agency.

INSECT RAVAGES EASILY MISTAKEN FOR THOSE OF THE BOLL WORM.

Owing to the fact that many planters attribute all of the shed forms or bolls which show any signs of insect attack to the work of the Boll Worm, it seems advisable to treat briefly of a few other insect depredations which are not well understood by them, and whose marks upon the fallen squares may readily be mistaken by an inexperienced eye.

*This was *Hexaplasta zigzag*, and is a parasite of *Phora* and not of *Aletia*, *Phora* being a scavenger on dead larvæ of all kinds in the South.—C. V. R.

†No black *Tachinid* eggs are known, and these were doubtless the eggs of *Euplectrus comstockii*.—C. V. R.

EUPHORIA MELANCHOLICA.

These beetles, together with the four species of larvæ immediately following, are perhaps of greatest importance in this connection. The first observation upon this species was made at Lamar, Mississippi. It led me to believe that the beetles did original boring into the bolls in order to reach the soft parts and their juices inside. Subsequent observations have not verified this opinion. The beetles observed at Lamar were found on a boll with their heads inserted into a small perfectly round hole about an eighth of an inch deep, or just deep enough to reach the soft parts beneath the pericarp. Few Boll Worms had been found in the field, and it seemed quite probable that the beetle had eaten out the cavities themselves. At Holly Springs, Mississippi, where the beetles were found quite plentifully in some fields, none were ever again seen under similar circumstances.

Flying about among the cotton plants during an afternoon they would be seen to alight on some boll which had been recently bored by the Boll Worm, but which had already been deserted by it. Here the beetle would sip of whatever juices there might be coming out of the injured boll. This is quite profuse at times, especially from those bolls of which the Boll Worm has but partially destroyed a certain section. From these proceeds a profuse frothing ferment, highly relished by the beetles, for occasionally two or three may be found at such bolls. When no boll with this tasteful exudate is found, they often alight on the tender-growing portions of a branch where leaf and flower buds may as yet be found but partially developed. They crowd down between these and puncture the tender and juicy peduncles, nearly always attacking those bearing flower buds. The small form supported by this peduncle dries up just as those bored by the newly hatched Boll Worm, and when dried enough to fall readily can not easily be distinguished from young Boll Worm work. With a view of determining whether the beetle ever did original boring upon cotton bolls if left to its choice, a number were placed on branches of cotton in a breeding cage, so as to be kept under observation. The results of these studies during confinement showed plainly that the beetle did its most injurious work by puncturing peduncles bearing forms or puncturing the very small bolls; in either case they were always shed. It therefore appears that if the beetle bores or eats into bolls at all, it certainly is an exceptional method of attack.

PLATYNOTA SENTANA.

The larva of this Tortricid moth is a small, green, slender, hairy worm, having a brown head, and is about half an inch long. It attacks forms and squares much the same as the young Boll Worm does. After the work is done and the worm has gone, its work can not be distinguished from young Boll-Worm ravages. These larvæ continue their

habit of feeding on forms or young bolls until about half grown, when they often migrate to the leaves, fold a portion of them together, and feed under cover. Many, however, remain with the young bolls, and reach maturity by feeding on them. They have been observed to bore half-grown bolls and destroy their contents.

CACCECIA ROSACEANA.

This Tortricid attacks the cotton in much the same way as the preceding species, and for that reason its depredations may be mistaken for traces of the Boll Worm. The worm differs from the preceding in that the head, dorsal surface of the first segment, and the legs are black.

PRODENIA LINEATELLA.

This fleshy worm was observed entering into nearly grown bolls and feeding on their contents. Its ravages are exactly like those of a nearly grown Boll Worm, and the two can not be distinguished.

NOCTUID (undetermined).

A cutworm, looking much like *Agrotis c-nigrum*, was found in a large breeding cage which had been placed over some cotton plants in the field. When placed over the plants, none of the forms or bolls had been injured, and no Boll Worms were found on the plants. Some time later several large bolls had been bored, and this worm was the only one which could be found in the cage. The evidence is therefore only circumstantial.

PLANT LICE.

(*Aphis gossypii* and *Aphis* sp.)

These small, greenish, mostly wingless, insects were especially abundant during the past season. Earlier in the season they are found principally on the leaves and younger growing portions of the branches, but frequently also on the young bolls between them and the involucre. Later in the season they are found most abundantly in the last-named localities, and in such great numbers on a single form or young boll that the latter soon fall off as a result of their puncturings.

In many cases the fruit thus injured simply dries and adheres to the branch. This fact often serves to distinguish it from Boll Worm work. Even when this is not the case their work is readily distinguished in that the form or square contains numerous small punctures.

THRIPIDÆ.

These small brownish insects during August were found in great numbers in the forming blossoms of the cotton plant. The feeding of these insects causes the form to drop soon after the blossom falls, if

not before. Such forms often present small black spots looking like small borings, but which are so numerous that they need not be confused with young Boll-Worm ravages. It must be noted that these signs of mechanical injury are not to be attributed to the Thrips. The shedding of these bolls is probably due to the fact that the work of the Thrips on the essential organs prevents fertilization. This insures the dropping of the fruit.

Many other species of the suborder Heteroptera probably puncture the pericarp of the very young bolls or their peduncles, in either case causing the shedding of the fruit. Careful examination will show that the injury is a puncture and should not be mistaken.

Neither of the first four species mentioned are numerous enough to cause alarm or extended damage, and are only mentioned to show that there is a certain small per cent of injury easily attributed to the Boll Worm which does not justly belong to that species.

REMEDIES.

TOPPING OF COTTON AND ROTATION OF CROPS.

These have both been justly pronounced inefficient as a means of fighting the Boll Worm (see Fourth Report U. S. Entomological Commission). It may be stated, however, that numerous interviews with farmers verified the opinion that topping did no harm, and that if "you could strike it right" it was an advantage. Experimentation is first necessary to show that it is practical and profitable to practice topping of cotton as an additional means of cultivation and the proper time to do so determined. When this is done it will depend largely upon whether that time falls within the period of greatest deposition by the moths. If so, no doubt some additional benefit will be derived by the destruction of the eggs deposited on the parts cut away in topping. But since the moth has been found to have such a wide range of deposition and the portion cut off in topping is so small in proportion to the whole surface of the plant exposed and suitable for deposition, it is not to be recommended to incur the expense of topping when nothing more is to be accomplished than the destruction of the few eggs which are likely to be found on the parts cut away. The rotation of crops can be of no avail against the insect, since it feeds equally well upon the corn or cowpeas, which are most likely to be rotated with the cotton.

FALL PLOWING.

This is to be urged for several reasons. It has been my experience, that where the cells of the Boll Worm pupæ are broken up and placed in loose, moist earth, which is allowed to be moist continuously and possibly to excess, that the pupæ die in a majority of cases even without freezing. It therefore appears that actual contact of the pupæ

with the cold moist earth sooner or later may cause its death. From this fact and the long continuous rainy season of the winter here it seems probable that great numbers of the pupæ will be destroyed if the soil be plowed late in December, so as to allow the loose earth to become well drenched by the almost continuous January rains. Subsequent rains will keep it quite wet, often perhaps, to excess. The pupal cells having been broken up, the wet earth directly affects the wellbeing of the pupæ. Even though the exposure to moisture alone should not prove entirely efficient, a light frost or the sudden cold wave changes of the atmosphere would greatly aid in the work of destruction. Certain it is, that a heavy frost occurring when the pupæ are in such condition would destroy all thus exposed. For this reason if the soil could be plowed in November so that the first black frost of the winter season could be utilized in killing exposed pupæ, great benefit would certainly be derived.

CORN AS PROTECTION TO COTTON.

Cornfields planted in July or August were always found to be badly infested with worms. Especially was this the case where the fields were small and near cotton fields. At the same time corn fields no larger but greater distances away from cotton fields were less infested and the cotton more so. As has previously been noted, this is explained by the fact that the moths feed mostly on cotton at night, but leave it to deposit on corn if found suitable and near by. Even late spring planting was found suitable for deposition in August, though maturing rapidly and having nearly grown worms in the ears. Especially suggestive were the observations made in cotton fields where a poor stand had been obtained and where corn had been planted in the "skips." In all cases the moths deposited freely upon the corn, though it was fast reaching maturity. Several of these cotton fields were carefully examined. The most extended search for worms revealed very few indeed, and the only possible conclusion to be arrived at was on the whole that the damage to the cotton was not so great as in those fields without the corn distributed through them. It is therefore evident that by the proper management of the planting of corn the latter could be made to answer as a great protection to the cotton against Boll Worm ravages. This management must consist in arranging the crops on the plantation so that green corn suitable for egg deposition shall be kept near or in the cotton fields in range of the moths.

It must be stated, however, that the corn, which is intended to act as a trap for the deposition of the eggs, and hence of the worms as soon as hatched, must be planted with a view of being cut as fodder as soon as a sufficient number of worms are found in the plants and before the worms begin maturing. From this it follows that the corn, which is to be allowed to mature and produce corn must be planted further away from the cotton fields in order that it may become infested as little as

possible. The importance of this will be appreciated when it is remembered that all the worms which mature on this corn and produce moths will furnish an additional supply to infest cotton and at the same time reduce the number trapped by the corn planted for that purpose. The corn cut for fodder should be disposed of in such a way as to insure the destruction of the worms found in the plants when cut. Each planting of corn which is to act as a trap should be planted soon enough to be in good condition for deposition as each brood of moths makes its appearance. This would require about three plantings for the northern portions of the cotton belt, and probably four in the southern.

The three plantings should occur about the first days of June, July, and August, respectively, and be cut whenever the worms are nearing maturity, to be sure to prevent their escape. By this method the least possible number of worms reach maturity. This consequently reduces their ravages on cotton later in the season to a minimum. This minimum is the most that can be hoped for, no matter what may be the remedial or preventive measures resorted to. This method would furnish a great source of fodder, and would tend to diversify Southern agriculture, a result greatly to be desired.

LIGHTS FOR ATTRACTING THE MOTHS.

Most of the experiments with lights for trapping the moths have proven unsatisfactory so far as economic results are concerned, but have been suggestive in that they have clearly marked out what will be necessary to make the use of lights more efficient.

While at Shreveport, Louisiana, in company with Dr. A. R. Booth, two kinds of patented lamps were taken into a large field of cotton to test their relative values and also to determine if possible the ease with which the moth could be attracted to lights. The lamps were lighted at 6:30 p. m. Quite a number of moths were seen flying about in the field as we passed through it, but up to half an hour after sundown but few insects of any kind were attracted. From that time until 8 to 9 p. m. insects of nearly every description were captured, but no Boll Worm moths. Sometimes a moth would be seen to approach the lamps but was more interested in feeding and depositing, always passing by or around without apparently noticing the lamps.

The lamps had been placed on pedestals high enough to bring them above the level of the top of the cotton plants, hoping thereby to attract moths from greater distances. In the mean time it was noted that the moth seldom attained to such a height during her flights about the cotton plants. Accordingly, on the evening of August 8, the same lamps were taken into the field, but placed so as to meet the habits of flight of the moth. This placed them at least on a level or a little below the plane of the top of the cotton plants. It was found that more moths approached and came nearer the lamp, and one was caught. In most cases, judging from the flight and actions of the moths, the lamps

were simply met with in their regular flight through the field for the evening, and that their course had not been materially influenced by the lights. Despite this fact, it was evident that the probabilities of trapping the moths at this height were increased. To vary the experiment, the lamp was carried through the field at about the height just mentioned, and one person walked along on each side some distance from the lamps so as to disturb the moths in that vicinity. In this way still more of the moths came near the lamps, and another one was caught. This is impractical, however, since the expense of labor is too great, at least until some means of making the lights more efficient is effected.

One of the lamps was provided with a shield constructed so that it would revolve with the wind, and thus prevent the lights from being blown out. This is entirely wrong, since the moth usually flies with the wind, in which case the light is of course shut off from view entirely. This defect renders the lamp entirely worthless for the end desired. In our experiments this shield was held or made stationary, and hence the defect did not enter or vary the significance of the results.

At Holly Springs, Mississippi, lamps were placed in cotton fields at various times during August. Some consisted merely of beer bottles filled with kerosene and a piece of unraveled cotton rope for a wick, and others of more powerful lamps. In all cases the lamps were placed in pans containing an inch or so of water, with a little oil on the surface, the whole being placed on a supporting pole or pedestal. The beer-bottle lamps burned satisfactorily, produced a good light, and attracted insects of nearly every order and kind except the Boll Worm moth, though these had been seen flying about in the field late in the afternoon.

On the night of September 9 these lamps were again taken into a cotton field having a small patch of corn near by; also a large patch of weeds, principally sneeze weed (*Helenium tenuifolium*). A lamp was placed in each at about the level of the tops of the plants, except the one in corn which was placed on about the same level as the ears on the plants. By 5 o'clock the moths were seen flying plentifully and ovipositing freely. The lamps were lighted at 6:15 o'clock. No insects of any kind were attracted until 7 o'clock, when moths of all kinds began flying near the lamps. By 7:15 a Boll Worm moth had been caught at the lamp in corn. At 7:25 at the lamp in cotton a Boll Worm moth flew near the lamp, alighted on the pedestal and rested. From here it flew up to a small boll in the direct light of the lamp, deposited an egg and flew off. From this time on many Ichneumonids and other Hymenoptera, as also great numbers of Microlepidoptera were caught. At 7:40 a Boll Worm moth was seen to fly through the flame of the lamp but was not captured. In corn at 7:50 a moth flew about the lamp and alighted on a blade of corn less than 2 feet away. For this act of defiance it was introduced to the cyanide bottle. Not many

moths were seen between 8 and 9 o'clock but the lamps were left burning all night to determine what would be the nature of the catch by the next morning. At this time the catch was examined and the results are tabulated below. For convenience the lamps in *Helenium*, corn, and cotton will be numbered 1, 2, and 3, respectively.

TABLE VII.

Hymenoptera.

	Ichneumono- nidae.	Miscella- neous.	Total.
1.....	10	4	14
2.....	9	3	12
3.....	12	2	14
Total for all.....			40

Lepidoptera.

Lamp.	Agrotis.	Helio- this.	Spilo- soma.	Miscel- laneous Noctuids.	Geome- tridae.	Pyrallidae.	Pteropho- ridae.	Miscel- laneous.	Total
1.....				17	15			300	332
2.....	2	1		1	30		27	300	361
3.....	1		1		25	20	26	250	323
Total for all.....									1,016

Diptera.

Lamp.	Tipulidae.	Miscella- neous.	Total.
1.....	8	25	33
2.....	40	10	50
3.....		75	75
Total for all.....			158

Coleoptera.

Lamp.	Epicauta.	Scara- baeidae.	Elatерidae.	Staphy- linidae.	Carabidae.	Miscella- neous.	Total.
1.....		2	2	25	8	25	62
2.....	7				2	50	59
3.....	2	1			6		9
Total for all.....							130

Hemiptera.

Lamp.	Homoptera.	Heteroptera.	Total.
1.....	200	100	300
2.....	200	100	300
3.....	200	150	350
Total for all.....			950

TABLE VII—Continued.

Neuroptera.

Lamp.	Chrysopa.	Total.
1.....	1	1
2.....	1	1
3.....	.....	.....
Total for all		2

Orthoptera.

Lamp.	Mantis.	Ecanthus.	Locus tidæ.	Total.
1.....	1	2	2	5
2.....	1	2	.....	3
3.....	2	.....	.....	2
Total for all				10

The above results show that the direct benefit to cotton plants, so far as known, is very small. At the same time such beneficial insects as the Ichneumonids, predaceous beetles, and the Praying Mantis are destroyed, and if trapping be systematically followed up the loss may indeed be considered greater than the gain.

These experiments led to the belief that the lights used were not brilliant enough for the intended purpose. Accordingly, an electric lamp was rented. The lamp is provided with a round burner and the flame produced is about 5 inches in circumference. When the chimney is placed over the flame the lamp is said to give a light equal to 100 candles. Experiments with this lamp in connection with the others were continued in the cotton fields during September. On the evening of the 13th both kinds were placed out. The night proved to be a damp cold one, and the dew fell early in the evening. As a result no Boll Worm moths and but few insects of any kind were trapped. Of this small number the parasitic Hymenoptera and predaceous beetles were greatly in the majority. The insects caught were such as are easily attracted to lights, and were quite equally distributed between the three lamps (two beer-bottle ones and the other the electric lamp). A rainy season began at this time and continued so that no further experiments with lamps could be made until October 4. At this time the electric lamp was placed in a cotton field to determine what would be the nature of the catch. Heliothids had been seen flying about in the evening while making some other observations, but none were captured by the lamp at night. The other insects trapped were about the same in kind as those already tabulated for September 9, only that the quantity captured by the electric lamp was about equal to that of all three of the others, and it had only been left burning until 10 o'clock.

October 20 the lamps were again placed out, this time one in a patch of cowpeas and the other some distance away in a small patch of corn which had been planted in July. During the day Boll Worm moths

were seen hiding behind the sheaths of the corn blades, while a number were also seen flying about the cowpeas. The one in the cowpeas was a beer-bottle lamp and placed about the height of the plants. The one in the corn was the electric lamp, and was placed about the height of the ears of corn. They were lighted at 6 p. m. At this time a few of the females were depositing on corn. At 7 o'clock some were seen to fly by the lamp but were not trapped. The parasitic Hymenoptera and smaller Lepidoptera had been caught in great abundance at both lamps. Returning at 10 o'clock to further examine the catch of the lamps, they were found to have been stolen and no further notes could be taken. The moths at this time were not very abundant and doubtless were but a portion of the last brood of the season. The moths seen flying by the electric lamp were near enough to have been stopped had the lamp been provided with long projecting wings and a larger pan to receive the moths as they fell. No Heliothids were observed at the beer-bottle lamp.

These light experiments, as will be seen from the record, were begun at the time that the midsummer brood was issuing abundantly, and hence also during the period of greatest egg deposition a little later. During this period, as has been stated, the provoking observation was made of seeing the female near the lights, deposit an egg in plain view, fly away and continue her work. It is evident, therefore, that the female is not easily diverted from the work of depositing eggs by the ordinary lights used. Later, when the experiments show that a few moths were trapped, it is also true that the period of greatest deposition had passed, and that, though dissections showed that a few eggs still remained together with a number of potential ova, the females had passed their prime. As bearing on this the following may be drawn from the observations of Dr. Booth: The insect contents of a globe of a 2,000 candle power arc light were examined continuously from September 3 to 13, inclusive. An average of 40 Heliothids were found for each night. Of these 1 in 6 or 8 were females, containing on an average from 30 to 40 eggs in the oviducts. The lamp tender reported that after September 26 no more moths were caught.

The fact that the moth was frequently seen to fly near the light, often as near as 2 or 3 feet, suggests that the lamps to be efficient not only must be brilliant, but must also have some wide and extensive wings extending from it in such a way as not to throw a shadow and to arrest, temporarily at least, the flight of the moth passing near by. If now the large pan and the lamp be provided with an additional inducement in the way of some strong smelling sweets, the moth thus arrested in its flight and its attention diverted from its evening work, if not falling into the pan, may be attracted a second time and be captured.

Unless it is found that the earlier broods are more easily attracted to lights it is questionable whether the inefficient lights so commonly used

by planters are to be at all recommended if nothing more is to be accomplished than the trapping of the Boll Worm moth, and for the following reasons: (1) But a small per cent are caught; (2) of these the great majority are males; (3) while some females are caught before having deposited many eggs, the greater per cent have passed their prime; (4) beneficial insects being more easily trapped are destroyed in too great numbers in proportion to the benefit derived from the destruction of obnoxious insects to warrant such inefficient warfare. These may all be included in the one general reason that the lights are only strong enough to readily attract beneficial insects but are powerless to attract the obnoxious insects desired until its most important work (deposition of eggs) has almost been completed.

POISONED SWEETS.

No field experiments were made with poisoned sweets, but a number were made with moths in the laboratory. The mixture was composed of 1 part of white arsenic dissolved in 20 parts boiling water; 4 parts of this solution were added to 3 parts of ordinary table sirup. The mixture was placed in a watch glass under a bell jar or sprayed upon cotton branches in a breeding cage. When the moths were placed in they always soon found the sweets and sipped of them. The result of all the experiments showed that the moths readily partook of the sweetened liquids. Those having sipped of the poisoned solutions died, on an average, within 30 minutes; the shortest time being 15, the longest 45 minutes. Experiments were also made upon a few other insects, mostly such as were considered beneficial. They were placed in the cages just as the moths had been and were found to partake of the sweets quite as readily and died as certainly. Thus in field experiments doubtless many beneficial insects will also be destroyed by the extensive use of the poisoned sweets.

The moths kept in cages for experimental purposes were fed by spraying unpoisoned solutions of the sweets upon the cotton branches. The moths fed readily and lived usually from 5 to 8 days.

The poisoned sweets used in the experiments in the laboratory contained no liquids which could liberate a strong odor such as is necessary in field experiments. These may be added in the form of beer or vinegar or perhaps any other liquid having similar properties.

It was demonstrated by the experiments in the laboratory that newly issued and old moths were alike easily induced to feed on the poisoned drops of sweets sprayed on the branches in the cages. It may therefore follow that if these poisoned liquids can be properly applied to the plants upon which the moths feed freely both at night and during the day, that females may be readily attracted to feed, and hence killed, during their entire period of deposition. It therefore appears probable that if some practical means is employed to apply these poisoned sweets properly and abundantly as food for attracting the moths that such

method of warfare against the adults will prove more efficient than any other alternative yet resorted to against them. It is evident, however, that to be most efficient, the poisoned sweets must be applied from the time when the moths begin feeding freely, and in such a way that they may meet with them readily in their flights about their food plants. The first will be accomplished if applied as early as 4 o'clock in the afternoon, in which case the poisoned liquids would also be exposed to their visits during the evening and night. The second can be attained by spraying the poisoned liquid upon the food plants. For those moths feeding during the day this must be applied principally to cow peas, for those feeding at night upon cotton.

The practicability of this method is yet somewhat questionable since probably one application of the poisoned liquids would be efficient only for a few days. It may further be questioned in that, as has been noted, the moths of any given brood issue quite scatteringly. At the same time it may be that applications of the poisoned sweets at intervals of 3 or 4 days will prove to be as practical as arranging for, and attending to, *light trapping* properly. My own efforts to experiment fully along this line were rather frustrated by rainy weather during September. This made experiments difficult and more or less indecisive.

The possible utility of combining poisoned sweets with lights has already been noted. The fact that females are readily attracted by sweets before many eggs have been deposited by her may become a sufficient additional inducement to entice those flying so near the lamps to linger a few moments longer and probably result in her capture. With these probabilities in mind it is to be hoped that the approaching season may be more propitious for experimental work and the Boll Worm more abundant.

PYRETHRUM.

Experiments with the dry powder.—The first of the following series of experiments with pyrethrum were made upon infested corn. The patch of corn was about two rods square and located near the center of the town (Holly Springs, Mississippi). It was a second planting and was only knee high at this time, August 19. The middle rows of the patch were selected and one row for each experiment taken. The powder was dusted from above down into the bud of the corn by means of a small cheese-cloth sack, double thickness.

EXPERIMENT 1.

August 19, 2:30 p. m. Mixture, equal parts lime dust and pyrethrum. The plants in the row by actual count contained 43 worms of various sizes.

Result.—Soon after dusting a few acted uneasily, began to crawl, and finally dropping to the ground, hid in the loose earth. This note applies more or less to all the experiments made with the powders. August 20, 10 a. m., 17 worms alive and feeding, 10 dead, 16 not present. In percentages this is 39.5, 23.3, 37.2, respectively. The living worms were mostly nearly mature ones which had penetrated far into the center of the bud and may not all have come in contact with the powder. The dead

ones were mostly composed of half or two-thirds grown worms. These notes again apply equally well to nearly all the other experiments with the powder. The following experiments will therefore be given more concisely.

EXPERIMENT 2.

August 19, 3 p. m. Mixture, 2 parts lime dust, 1 part pyrethrum. Number of worms in plants, 43.

Result.—August 20, 11:30 a. m., 29 living, 10 dead, 13 not present, or 46.5, 23.3, 30.2 per cent, respectively.

EXPERIMENT 3.

August 19, 3:30 p. m. Mixture pyrethrum full-strength. Number of worms 54.

Result.—August 20, 12 m., 25 living, 8 dead, 21 not present, or 46.3, 14.8, 33.9 per cent, respectively.

EXPERIMENT 4.

August 19, 4 p. m. Mixture equal parts lime and pyrethrum. Worms not counted.

Result.—August 20, 2 p. m., 19 living, 12 dead, or 61.3 and 33.7 per cent, respectively.

EXPERIMENT 5.

August 19, 4:30 p. m. Mixture 2 parts lime, 1 part pyrethrum. Worms not counted.

Result.—August 20, 2:30 p. m., 26 living, 8 dead, or 76.5 and 23.5 per cent, respectively.

EXPERIMENT 6.

August 19, 5 p. m. Full strength pyrethrum. Worms not counted and only a part of the row dusted.

Result.—August 20, 3 p. m., 5 living, 6 dead, or 45.5 and 54.5 per cent, respectively.

The dead worms of experiments 1 to 6 were kept, for raising any possible parasites, until September 3, when they were found to be perfectly dry and were thrown away. No parasites had issued from them.

As checks on experiments 1 to 6 it may be stated that in examining the rows carefully to count the actual number of worms in the plants no dead worms were found. Numerous other observations upon corn of a similar age, and which had not been dusted, verified the one made while counting the worms.

The first 6 experiments and their results may be tabulated for convenience as follows:

TABLE VIII.

Experiment.	Substance used.	Living.	Dead.	Absent.	Probable benefit.
1.....	Lime and pyrethrum, equal parts....	39.5	23.3	37.2	60.5
2.....	Lime 2 parts, pyrethrum 1 part.....	46.5	23.3	30.2	53.5
3.....	Pyrethrum, fullstrength.....	46.3	14.8	38.9	53.7
4.....	Same as experiment 1.....	61.3	38.7	.....	38.7
5.....	Same as experiment 2.....	76.5	23.5	.....	23.5
6.....	Same as experiment 3.....	45.5	54.5	.....	54.5
Averages		52.6	29.7	17.7	47.4

EXPERIMENT 7.

August 20, 10:45 a. m. Dusted the 17 living nearly-grown worms of experiment 1 with full strength pyrethrum, and placed them in a closed mailing box without food.

Record—11 a. m., some are beginning to be restless; 12:30 p. m., all are quiet; 1:45 p. m., one almost dead, others jump when touched; 4:20, p. m., one dead, others as before.

August 21, 11:30 a. m. Some have become quite active again, and as a result 4 were bitten, 3 are dead, 6 others alive and active, while the rest were probably eaten. The active ones were placed in a breeding cage, and provided with branches of cotton having leaves and bolls. Some died later and a few matured.

EXPERIMENT 8.

August 30, 4:30 p. m. Eighteen of the living worms from experiments 4, 5, and 6 were well dusted with lime. Nine were placed in each of two closed mailing boxes. This experiment was for the purpose of having a check on any possible effect of the air-slacked lime on the worms.

August 31, 11:45 a. m. In one box two were injured and died. The rest alive and active. In the other box all are well and active. Both lots were then placed on branches of cotton in breeding cages. All began feeding; a few died later, but most of them matured.

EXPERIMENT 9.

September 11. Boll Worm in a boll with posterior segments protruding. Dusted this with full strength pyrethrum at 9:15 a. m.; no immediate effect was noticeable; 11:30 a. m.; worm has turned round: head almost protruding; not feeding; 3 a. m., has turned round now to position same as when dusted, and is feeding. With a pair of forceps placed some pyrethrum powder on the body of the worm in the hole. Did not effect the worm noticeably for five to ten minutes.

September 12, 8:30 a. m. Has left the boll and is in the upper corner of the cage still alive and active.

September 13, 8 a. m. Has returned to the boll it had left, and is feeding. Dusted the protruding portion with pyrethrum. In the afternoon the worm was found crawling about in the cage, but appeared to be full grown and searching for a place to pupate. Placed back on the branch again.

September 14. Worm still on the boll and is active, but not feeding. Particles of pyrethrum are found adhering to the body. The anus is swollen and inflamed, producing a watery exudate. This may be due to the effect of the pyrethrum, for this is the portion of the body which was usually protruding from the hole in the boll and received most of the dusting. The worm was placed in a partially opened form.

September 15. Has eaten the form almost entirely.

September 16. Crawling about in cage. Placed on a branch.

September 17. Crawling about in cage. Has shortened some and is preparing to pupate. Placed in a tin can with earth to allow it to do so. Pupated September 21. Pupa still alive October 3, when it was placed in alcohol as a specimen.

In one instance, when a worm had been experimented with in a similar way to Experiment 9, the worm went down to corner of the cage (which was a newly made one), webbed together the loose sawdust found there, and pupated in the cell thus formed.

EXPERIMENT 10.

September 20, 5:30 p. m. Marked five bolls in which Boll Worms were feeding and a portion of the body protruding. At 5:40 dusted profusely with pyrethrum, full strength.

6 p. m. The first worm ceased feeding and left: can not be found. The second was entirely in boll, but came out and is twisting about uneasily: finally it fell to the ground in convulsions, tumbling over on its back as if to scrub off the powder. The third ceased feeding. The fourth was a young worm and is not to be found. The fifth still feeding.

6:15. The second is still in convulsions and can not crawl well; it is one about two-thirds grown. The third has fallen to the ground, but is crawling into loose earth. The fifth continues feeding. The last two are nearly grown worms, and doubtless will take some time to become badly paralyzed. At 6:30, while making other observations, it became dark, and could not find the worms again.

A number of individual experiments with grown worms, both in the laboratory and open air, were made. The worms were well dusted with full-strength pyrethrum and were allowed their pleasure as to their abode afterwards. They always crawled into the loose earth as soon as possible, and as long as they were observed showed signs of recovery. Other experiments similar to Experiment 9 are omitted because their results were practically the same in all cases.

DECOCTIONS OF PYRETHRUM.

Seven pints of rain water were brought to boiling in an open pan; 12 grains of pyrethrum were then stirred in and boiled for 15 minutes. The whole was then strained so as to get out most of the powder. This decoction was made on the afternoon of September 19, but owing to a threatening rain was kept in sealed Mason jars until the next day, when the decoction was sprayed on bolls containing Boll Worms. The following strengths were used: Full, two-thirds, and half.

EXPERIMENT 15.

September 20. The bolls with worms in had all been found and marked during the forenoon. The day was warm and sunshiny. In the afternoon it was found that one of the worms had changed bolls since morning observation. At 2:40 p. m. full strength of the decoction was sprayed on each of six bolls containing Boll Worms. Four of the six were not in bolls, but between them and their involucre. The greater portion of the plants surrounding the boll was also sprayed.

2:50. No uneasiness manifested by any.

3:15. Five as before; one half-grown worm has moved and can not be found.

3:45. No change; has not affected the worms yet.

4:10. None feeding; no change.

5:00. One feeding; others as before.

5:50. None feeding.

September 21. Two worms still in place; one feeding, the other just molted: two others finished the bolls in which they were found and have disappeared; the other one is in boll in laboratory.

September 23. All have gone but one; this one went to another boll, fed, and has just molted; an hour later it was found devouring molted skin.

EXPERIMENT 16.

September 20. Equal parts decoction and rain water. At 3 o'clock sprayed five bolls, each containing a Boll Worm. Four were not feeding, but resting between boll and involucre; the other was in boll feeding. None had changed position since morning observation.

3:25. One seems to be a little uneasy ; others manifest no anxiety.

3:42. The one in boll has turned around and is poking its head out of the bolls ; another has moved and gone into a blossom ; the others same as before.

4:10. One is feeding ; all the others quiet and not feeding.

5:00. One feeding ; others no change.

5:50. None feeding.

September 21. Four still in place, all feeding ; the other has left the plant.

September 23. One still in place, but has about destroyed its boll. The others have done so and are gone.

The record of the experiment with two parts decoction and one part rain water is omitted because of the similarity of results to those of Experiment 16.

CHECKS ON EXPERIMENTS 15 AND 16.

September 20. At first three, but later five more worms were marked as checks.

2:30. One entirely in boll, feeding ; another, nearly mature, resting and not feeding ; a third, very young one, is feeding.

5:00. Checks all in place feeding.

5:50. All but very young one feeding. Made a search for more worms ; found five, all of which are in bolls feeding.

September 21. One still in boll, but not feeding.

The small worm has bored through a form and is feeding. The nearly matured worm has destroyed its boll and has gone away.

The result of all the experiments with pyrethrum is, on the whole, negative. Before treating more fully of the results of the experiments it must be stated that the corn plants, cotton bolls, and Boll Worms were more thickly and thoroughly dusted or sprayed than it would have been possible to do by dry method of application which would be inexpensive enough to be practical. There is a special difficulty in the case of cotton. At the time when the powder would be most efficient, that is, when the worms are yet less than half grown, they are found principally at work in forming blossoms and very young bolls. In these the involucre so completely and effectually inclose the portions in which the worms are at work that it is practically impossible to reach them. It is well known that the young form or boll is sensitive to excessive rains, and their involucres, it seems, are to a great extent a provision of nature to protect the tender young bolls from such injury. To whatever extent this may be the case, it is certain that their involucres make it exceedingly difficult to reach the forms and bolls beneath them by any of the methods of spraying, and therefore also to all decoctions or solutions of whatever kind.

Upon corn before it has tasseled the powder may be used with greater success, as will be seen from a study of Experiments 1 to 6. From these we find that a certain benefit of about 30 per cent. is obtained, with a possible benefit of about 47 per cent. This last is too high, however, as some of the worms which leave do so only temporarily and to recover, after which they return. We also find that the young worms are much more susceptible, or at any rate less able to resist the effect of the pyrethrum. Consequently of the worms killed, the great majority were half or less than half grown. From the behavior of the grown or nearly

mature worms in all the experiments, it is evident that they strongly resist the effects of the powder, and if ample opportunity is given to escape to the ground or loose earth, may often entirely overcome its influence and recover. Whether on corn or cotton, it must be admitted that the protection is only temporary. This is shown by the fact that in some of the experiments undisturbed individuals entered bolls with impunity soon after dusting and after the first worm had retreated, or even the same worm going back and feeding upon the boll from which it had been driven, presumably, by the pyrethrum.

As has been noted, there is a certain benefit derived from the application of the powder to young corn before tasseling. It is just to consider that the pyrethrum was at a disadvantage, in that it was not applied early enough to catch the worms before they had become so nearly grown or had entered far into the bud. If it had been applied earlier a much greater per cent of the worms then present would doubtless have been destroyed. Such being the case, the use of pyrethrum may prove to be a decided advantage in coöperation with the plan of planting corn as traps for egg deposition, and hence the worms when these are hatched. This can be done by thoroughly applying pyrethrum of about one-half or third dilution with lime to the corn plants at a time when the worms are found to be about half grown. By doing this the time of cutting out corn to destroy the worms it contains will be delayed for a time longer, and hence also be exposed to the depositions of the moth for a greater period. Experiments in this direction will be taken up extensively this season.

The powder being thus limited in its efficacy, especially on cotton, it is not surprising that decoctions of the powder prove to be even less effective. As will be noted from the experiments with the decoctions when compared with the record of the checks upon the same, little more was accomplished than to temporarily arrest the feeding of the worms. It is true some of the worms changed bolls during the afternoon, and others which were in bolls came out, but it must also be noted that the same action was taken by other worms which were under observation and which had not been sprayed. There is some question, therefore, that the decoction was directly accountable for the action of the worms upon which it was sprayed.

This doubt is further increased from the fact that it was often noted in worms which had been marked for observation that they very frequently changed bolls or even plants during midday or afternoon.

OTHER VEGETABLE INSECTICIDES.

The work upon vegetable insecticides was assigned almost entirely to Prof. Jerome McNeill, Fayetteville, Arkansas. He has been as unfortunate as myself in being unable to obtain plenty of Boll Worms to experiment with. Progress was further impeded by unpropitious weather. For this reason the greater portion of the time was occupied in collecting

such roots, plants, flowers, and fruits as might, upon experimentation, prove to have insecticidal properties. This was undertaken with a view of discovering if possible some product easily grown in the infested regions through the cultivation of which it might be possible to provide for an insecticide which would be cheap and accessible to all. From these various collections Professor McNeill has made numerous extracts, emulsions, and decoctions, some of which he informs me are quite promising, and which are on hand to experiment with when opportunity offers. As this part of the work has, therefore, not been completed for the reasons stated, I shall at present give only a summary of Professor McNeill's letters and report of progress during the past season.

(1) Alcoholic extracts and decoctions have thus far been, on the whole, unsatisfactory.

(2) Extracts and extract emulsions of the various vegetables or parts thereof seem to be promising. Of these kerosene, kerosene ether, gasoline and benzine extracts, and emulsions of pyrethrum are perhaps most important.

(3) Of the plants experimented with, *Lobelia syphilitica*, *L. cardinalis*, probably *L. inflata*, and *Arisaema triphyllum* are among the more important as giving promise of good results. They have been shown to possess insecticide properties, but to what extent and how best utilized remains an open question.

(4) An exceedingly dilute solution of potassium cyanide is an efficient insecticide, but its effects on the cotton plants has not yet been determined.

METEOROLOGICAL CONSIDERATIONS.

Of these rain, humidity, and temperature are the principal phenomena to consider. What relation these may have to the various stages of the transformations of *Heliothis*, the following tabulated data may serve to indicate. The averages of humidity and temperature are given for the entire period covered by each example:

TABLE IX.

EGG.

When deposited.	When hatched.	Duration.	Rain, number of days.	Temperature.		Humidity.	
				Max.	Min.	Max.	Min.
Night, Aug. 5-6.....	Aug. 10, 10 a. m.....	3½	3	93	74	88	56
Night, Aug. 8-9.....	Aug. 10, evening.....	2	0	94	73	87	63
Night, Aug. 14-16.....	Aug. 18, 9 a. m.....	3½	1	84	72	(*)	(*)
Night, Aug. 15-16.....	Aug. 18, 9 a. m.....	2½	0	84	72	(*)	(*)
Night, Sept. 19-20.....	Sept. 24, evening.....	5	5	79	67	(*)	(*)
Night, Sept. 20-21.....	Sept. 25, morning.....	4½	5	78	64	(*)	(*)
Night, Sept. 21-22.....	Sept. 25, morning.....	3½	4	77	67	(*)	(*)

* Data for humidity at Holly Springs, Miss., could not be obtained. The first two are from Shreveport, La., where eggs were under observation.

TABLE IX—Continued.

LARVA.

When hatched.	When matured.	Duration.	Rain, number of days.	Temperature.		Humidity.	
				Max.	Min.	Max.	Min.
				°	°	°	°
August 9	August 23	15	1	91	71	88	65
August 10	August 25 (died)	16	2	91	71	88	67
August 18	September 7	21	6	82	68	.....	.....
August 18	September 12	26	7	82	68	.....	.....
September 25	October 12 (two molts) ..	18	7	73	60	.....	.....

PUPA.

When pupated.	When issued.	Duration.	Rain, number of days.	Temperature.		Humidity.	
				Max.	Min.	Max.	Min.
				°	°	°	°
August 9	August 20	11	0	91	71	89	65
August 23	September 2	10	2	91	68	82	60
August 28	September 12	15	5	81	68	.....	.....
August 28	September 13	16	6	80	68	.....	.....
August 28	September 16	19	8	79	67	.....	.....
August 28	September 17	20	8	79	67	.....	.....
August 31	September 27	27	14	79	66	.....	.....
September 4	September 20	16	7	80	67	.....	.....
September 7	September 30	• 22	15	79	68	.....	.....

These data may be studied in the order given.

EGG.—For the first two lots the temperature is the same with only a slight difference in humidity, but during the period of the first lot rain fell for a part of the time on 3 successive days; during the second none fell at all. Under these conditions the duration of the first lot was $1\frac{1}{2}$ days longer. The period covered by the next two lots of August 15 and August 16, furnish about the same conditions with the same results. The next three lots were deposited much later in the season, had lower temperature and excessive rains, 6.37 inches having fallen from September 22 to 25 inclusive. The duration of the egg state as a result was much prolonged. There is no check on this lot, however, since no eggs under direct observation were hatched during that season with the same low temperature but without the excessive rains. From general observations, however, there is no question but that low temperatures also prolong the duration of the egg state, the same as the rains seem to have done in each of the two first lots mentioned.

Larva.—The first two larvæ were reared under almost exactly similar conditions and, as will be seen, matured almost at the same time. As compared with those that follow the duration is of interest, as there was but little rain and a high temperature. The next two were worms hatched from the same lot of eggs, and, as is seen from the table, were reared under exactly similar conditions. Despite this, the difference in time of maturing is 5 days. This can only be accounted for by the peculiarities of the species, such as have been previously discussed. The difference, as compared with the two preceding, was principally due to the much lower temperature. If, with the abundant rain during that

period, the temperature had been maintained as high as in the first, the worms would have matured more rapidly. This is verified by noticing the retardation of growth of the last worm recorded in the table. This worm had only molted twice after 18 days. The temperature during this period was 18° lower than that of the first two and 9° lower than that of the second two. General observations established this fact concerning the feeding of the worms, viz: that a moderate amount of rain with high temperature was least suited to their most vigorous feeding and growth, and consequently their earliest maturity. The same amount of rain, however, with a much lower temperature, is as much a disadvantage, and increases the retarding effect, which the lower temperature itself would have had. But again, high, dry temperatures are avoided by the worms, which during that time feed less vigorously, and thereby prolong their larval existence some.

Light frosts began (both in Mississippi and Louisiana) as early as October 27, and were more or less continuous from that time on. At Holly Springs, Mississippi, a killing frost occurred October 31, which froze and entirely blackened the cotton plants. At Shreveport, Louisiana, however, the cotton was not entirely frozen and blackened until about December 4. As has been previously noted, worms of nearly all stages were found at both localities a short time previous to the killing frosts, by which latter the younger ones were quite certainly killed.

Pupa.—For the first of the pupæ recorded it is found that a moderate amount of rain with high temperature shortens the duration of the pupal state. From the remaining ones it is found that with but little variation in the low temperature, which alone would have prolonged the duration, the excessive rains greatly added to the delay.

In general, then, it may be stated that the duration of the various stages of *Heliothis* are shortest under high temperatures with moderate rainfall; longer, except in egg and pupa, when a high, dry temperature is maintained; longer still with much lower temperature; and yet again longer with lower temperature and excessive rains.

Some atmospheric conditions also noticeably influence the behavior of the moths. The hot weather, dry, or somewhat rainy, seems to have but little diverting effect on the habits of the moths. When the temperature is much lower, and is accompanied with much rain, the moth adapts itself to the condition of things. The excessive rains last season continued late in the evening and into the night. This of course covers the period of feeding and deposition. This seemed to have the effect of inducing the moths to fly and feed more freely during the middle of the afternoon, when it was clear and warmer. When the rainy spell began to be a protracted one, the females were frequently seen at 3 o'clock during the warm sunshiny afternoons busily engaged in depositing their eggs. The instances in which deposition was observed in daytime were confined mostly to this period, though some were observed under normal conditions. From this it follows that to a certain

extent, at least, the imagoes adapt themselves to unfavorable conditions, and that their period of egg deposition, on the whole, is not much influenced by such conditions. Their progeny, however, as has already been noted, suffers materially.

As bearing on the abundance (or rather scarcity) of the Boll Worm the past year, I quote from the report of Professor Fulton for 1890 as follows: "The most important irregularities of the year were the unusually high temperature in January and February, with a marked deficiency of temperature in March." During the period of high temperature in January, and especially February, it may be that many of the moths issued. If so, the cold period in March quite likely killed many of those which had issued. In the Red River section of Louisiana the Red River overflowed badly in spring, and planting of both corn and cotton was delayed until late in May and some in June. This necessarily delayed finding suitable host plants for the moths which had issued during April and May to deposit on, and doubtless a large per cent of their progeny failed to survive. In some localities also corn and cotton had been planted and was large enough for the moths which had issued to deposit upon when the river overflowed. As a result the corn and cotton both were drowned, or at any rate stunted so that it was all plowed under and planted a second time. By this process doubtless many of the first brood of worms were destroyed. From these reasons the second brood and consequently all subsequent broods were in all probability greatly reduced.

From all the information gathered through observers of the U. S. Signal Service it is certain that the boll-worm depredations are much more extensive in the southern portion of the cotton belt. There is, therefore, no question but that the future work on the Boll Worm should be carried on principally in that region.

INSECT DISEASES.

The work upon insect diseases has formed an important part of the investigation. At the present time, however, it would be unwarranted and hazardous to enter largely into a report upon the work done and in contemplation, or to draw conclusions. I shall therefore give but little more than a synopsis of the present condition of the work, and will reserve acknowledgments to those who have contributed in any way for a more detailed report in the future.

The first thing to be done in preparing for such work was to equip and arrange for a bacteriological laboratory. Some time was spent at Shreveport, Louisiana, in coöperation with Dr. Booth (who assumed charge of the work for the season) towards accomplishing this end. Hot-air and steam sterilizers were designed and a good workman soon had them in condition for use. The other supplies immediately necessary were ordered. These have been added to as the progress of the

work demanded, until now quite a complete laboratory has been fitted up, sufficient to carry on to a finish all the work and experimentation which it will be possible to execute.

The diseased insects and worms from which the cultures on hand have been made were obtained from various sources from entomological workers throughout the country.

Extensive and conclusive experiments with the insect diseases on hand were not made for the same reasons stated by Professor McNeill. The status of this portion of the work is, therefore, much the same as the latter, viz, ready for extensive and thorough work during the approaching season. The few observations made are encouraging, but do not warrant any definite and positive statements at this time.

It seems highly probable that the Boll Worm is readily susceptible to the cabbage-worm disease. Dr. Booth in one instance fed Boll Worms upon diseased cabbage worms, which Boll Worms later died. Cultures were obtained from these dead Boll Worms. Mounts from the cultures were made later and studied with a microscope. Micrococci were present in great abundance. At Holly Springs, Mississippi, some Boll Worms were accidentally placed in a breeding cage in which dead cabbage worms had been temporarily placed. A number of these Boll Worms died at various intervals. The dead worms were sent to Dr. Booth, who made cultures from their dead and decaying bodies. Examination of mounts made from these cultures again showed micrococci in abundance. The above evidence is not direct and positive; is merely indicative, and at best unscientific. It consists simply of observations noted during the progress of the work, and simply indicates that scientific experiments may prove successful.

Though no experiments could be made upon the Boll Worms with *other* insect diseases, the interesting and important discovery was made at Holly Springs, Mississippi, that the Boll Worm itself is subject to a disease. The disease is not confined to the larval stage, but has been obtained from all the stages of the species. Two females issued on the night of September 14. On the second day, it was noticed that the moths were rather sluggish and that the abdomen was greatly distended. By the next day the females were absolutely helpless, and the abdomen so decomposed that it barely held together while pinning the moth. The last signs of life of the moth consist of peculiar alternate openings and closings, contracting and expanding of the anus and genital organs. At the time it did not occur to me that it was a disease of the species, and it was only the peculiar manner of the dying of the moth which had attracted my attention. Hence it was that the moths were simply pinned and placed in insect boxes. This was done September 17. November 28, the abdomen of the moth was accidentally broken off and the internal parts were found to be partially liquid. From this partially liquid portion tubes of beef broth were inoculated, as also from a whitish, waxy, gelatinous substance in the extreme poste-

rior end of the abdomen. A culture was obtained from the waxy portion, and the microbe is different from any of the others studied. It is possible that the cultures obtained from the moths after so long a time are non-pathogenic microbes, instead of the one which produced the disease of the imago. No positive statements will therefore be given until experiments have been made. Cultures from the egg, larvæ and pupæ are in stock, and, so far as examined, are all exactly alike. This disease can not have been mistaken for any other, since it was noted before any of the others were on hand. Thus, having probably found the Boll Worm subject to a disease perhaps peculiar to itself, it remains to be seen whether it is contagious and easily disseminated for infection.

In addition to this, a disease of each of the two larvæ whose ravages are easily mistaken for those of the Boll Worm was also discovered at Holly Springs, Mississippi. The two species are *Prodenia lineatella* and the undetermined Noctuid spoken of. In fact the disease of each was so prevalent, that but few of the worms were found, and of those found all but one, which had been placed in alcohol, died of the disease. No great apprehensions need therefore be had concerning these two species.

Diseases of *Agrotis messoria*, *Nephelodes minians*, as also of the large tomato worm, are at hand in the form of cultures.

Cultures from all these sources were begun in August, 1890. By the regular methods for such work pure cultures have now been obtained and are transferred from time to time to fresh media, in order to continue the healthy growing germs through the winter and in good condition for the approaching season's experimental work. In this way a vast number of cultures in fine condition are on hand, and it is to be hoped that abundant opportunity may be offered this season to execute extensive and thorough experiments.



